

DUICKERS, CABLES, AND NETS: A CULTURAL ECOLOGY
OF HUNTING IN A CENTRAL AFRICAN FOREST

By

ANDREW J. NOSS

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LIST OF ACRONYMS

BSP	Biodiversity Support Program
CAR	Central African Republic
CFA	Communauté Financière Africaine
COICA	Coordinadora de las Organizaciones Indigenas de la Cuenca Amazonica
EIL	Experiment in International Living
ICDP	Integrated Conservation and Development Project
IUCN	International Union for the Conservation of Nature
USAID	United States Agency for International Development
WCED	World Commission on Environment and Development
WCED	World Commmission on Environment and Development
WCS	World Conservation Strategy
WRI	World Resources Institute
WWF	World Wildlife Fund and World Wide Fund for Nature

Abstract of Dissertation Presented to the Graduate School
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By

Andrew J. Noss

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This dissertation analyzes the relationships between ecological and human systems, and between biodiversity conservation and socioeconomic development, by focusing on the role of hunting. The analysis addresses two research questions. First, how does hunting affect wildlife populations? Are harvests sustainable? Second, what is the economic importance of hunting, relative to other economic activities, for human populations?

The two primary hunting methods in the rainforests of the south-western Central African Republic are cable snare hunting by immigrant ethnic groups, and communal net hunting by BaAka Pygmies. Data collection is based on participant observation, activity records, interviews, market surveys, and biological measurements of captured animals.

The primary game species for both hunting methods are the brush-tailed porcupine *Atherurus africanus* and the duikers *Cephalophus monticola*, *C. callipygus*, and *C. dorsalis*. Net hunters encounter and capture few other species. But virtually all mammalian species, as well as several birds and reptiles, are captured by snares.

Net hunters probably overexploit *C. monticola* and *C. dorsalis*, whereas snare hunters probably overexploit *C. callipygus*. Both hunting methods are practiced in most areas, in addition to gun hunting. Therefore current hunting by all methods combined is probably excessive for all game species. In addition to animals killed and recovered by hunters, snares lose many animals to decomposition and scavengers, and many others escape with injuries.

Although both hunting methods produce meat for subsistence and for sale in local markets, snare hunting is primarily market-oriented, while net hunting is primarily subsistence-oriented. Both groups of hunters pursue mixed subsistence and economic strategies, combining hunting with other activities.

Human populations are increasing through population growth and immigration, while economic expectations are rising. At the same time, hunting ranges are declining as other land use systems expand. Wildlife is an open access resource belonging to the state. Local hunters do not

conserve or manage wildlife resources: they believe that wildlife cannot be exterminated by snares or nets. Even if wildlife is exterminated they will pursue other activities or move elsewhere. Under these conditions, conservation and development are incompatible.

CHAPTER 1 INTRODUCTION

This dissertation analyzes the relationships between ecological and human systems by focusing on an activity which links the two systems, namely wildlife exploitation. Cultural ecology provides the theoretical framework for the analysis. Accordingly, two parallel topics are defined. The first topic relates to the ecosystem, in particular the theory and practice of biodiversity conservation. Of primary interest from a conservation perspective are the impacts of hunting on wildlife and the sustainability of wildlife harvesting. The second topic relates to the human system, and the theory and practice of socioeconomic development. Of primary interest from a development perspective is the economic importance of wildlife exploitation, as well as the relations between hunting and other subsistence or economic activities. Each chapter addresses both themes and explores the links between the two.

The research context is the Bayanga rainforest region of the south-western Central African Republic (CAR). The local population consists of several ethnic groups, including both long-term local residents and recent

immigrants. Current economic activities in the region are a continuation of historical resource exploitation and land use patterns: logging, diamond mining, and coffee plantations. In addition, people engage in cultivation, fishing and hunting for economic and subsistence purposes. The most recent regional development is the creation of a national park to conserve a portion of CAR's remaining forests and wildlife.

Research depends primarily on participant observation of legal and illegal hunting activities. Additional data are collected through activity records, interviews, market surveys, and biological measurements of captured animals. These methodologies generate two types of data: first, ecological data regarding the wildlife resource base and the impacts of exploitation on wildlife populations; and second, economic data on the role of wildlife exploitation in the local economy.

Chapter 2 locates the research in the context of geographical and anthropological theory, specifically in cultural ecology. In addition, the chapter relates the research to the literature on biodiversity conservation and socioeconomic development, and on efforts to integrate the two. The section concludes by examining the relations between hunting, on one hand, and both conservation and development on the other.

Chapter 3 describes the ecosystem and the human system in the research area. The ecosystem, like other tropical rainforests, is complex. This section describes in particular the resource base represented by the four primary game species: the brush-tailed porcupine *Atherurus africanus*, and the duikers *Cephalophus callipygus*, *C. dorsalis*, and *C. monticola*. Of particular importance are estimated population densities of these game species in the Bayanga region, and predicted sustainable harvesting rates. Components of the human system include political authorities, economic activities, and population centers. Change in each of these components over time in turn affects patterns of wildlife exploitation. In order to illustrate the influence of hunting on relations between the ecosystem and the human system in the Bayanga region, the chapter concludes by discussing the following cases and issues: the ecological impacts of human activities, elephants, hunting legislation, bushmeat markets, and currency devaluation.

Chapters 4 and 5 analyze the two primary local hunting methods--cable snare hunting and communal net hunting respectively--practiced by two distinct groups of hunters. In each chapter, a description of the research methodology and the hunting method precedes a discussion of the primary research questions:

- 1) What are the impacts of the hunting method on wildlife in terms of species distribution, sex ratios,

and age classes captured or injured? Is current offtake by the method sustainable?

2) What is the economic importance of the hunting method in terms of employment, time allocation, and returns? What is the relationship between hunting and other subsistence and economic activities?

Chapter 4 examines cable snare hunting by Bayanga residents of several ethnic groups, based on participant observation of snare hunting trips from September 1993 to December 1994. Most snare hunting requires overnight trips to check snare lines. Cable snares are illegal everywhere in CAR because they are indiscriminate in capturing and injuring virtually all mammals, as well as several species of birds and reptiles. But many people depend on snares to obtain food, as well as income from the sale of meat in local markets. Cable for snares is much easier and cheaper to obtain than the alternative--firearms. Snare hunting can be a full-time occupation for weeks or months, though Bayanga residents prefer formal employment.

Chapter 5 examines communal net hunting by the BaAka of Mossapoula, based on participant observation of net hunts from September 1993 to November 1994. Most net hunts are day trips from Mossapoula, while in other cases groups hunt from temporary camps established in the forest. Net hunting is legal outside protected areas, and targets the most abundant small/medium-sized terrestrial mammals--the porcupine and duikers mentioned above. Net hunting also provides food and income, but is one of several subsistence

and economic activities among which Mossapoula residents alternate on a daily basis.

Chapter 6 compares the two hunting methods, in terms of their implications for the ecosystem and the human system. Chapter 7 concludes by reviewing the role of hunting within the cultural ecology framework. The chapter also addresses the implications of hunting for biodiversity conservation and socioeconomic development across tropical forests, and proposes recommendations for further research.

The following comments are general explanatory notes on the text and the fieldwork.

BaAka: I use the general term "Aka" which unites the Bayanga area Aka with those in the Lobaye area of CAR and those in northern Congo, all of whom share a single language. The Aka have been extensively studied by Serge Bahuchet and others. Other terms in the literature for the same people are "Biaka," "Babinga," and "BaMbenga." Louis Sarno's (1993) more local term "BaBenzele" refers to the Bayanga region BaAka. The BaAka are linguistically and culturally distinct from the Baka of Cameroon and CAR west of the Sangha river. When discussing the residents of Mossapoula, I refer only to the BaAka residents.

Pygmy: The BaAka are one of several African forest peoples, traditionally hunter-gatherers, known as "Pygmies." The term refers to their small stature, and dates back to Aristotle, Herodotus, Homer and Pliny (Demesse, 1978). When

referring to particular ethnic groups, I use the name the group calls itself--Aka, Efe, Mbuti, etc. I have found no alternative that refers to these groups collectively.

Bilo: I use the BaAka term "Bilo" to refer collectively to all non-BaAka ethnic groups in the Bayanga region (Kisliuk, 1991; Kretsinger, 1993). Other terms used in the literature to refer to Pygmies' neighbors are not accurate in the Bayanga context. The term "Bantu" is incorrect, as several ethnic groups such as the Gbaya are not Bantu-speaking, while Aka is a Bantu language (Bahuchet, 1985c; Bahuchet and Thomas, 1986; Greenberg, 1966). The terms "villagers" and "farmers" no longer provide meaningful distinctions where the BaAka too live in villages and cultivate farms. When discussing Bayanga residents, I refer only to Bilo residents.

Orthography: In the case of river and town names, I use the French orthography for consistency with other maps produced for CAR. In the case of personal names and words in African languages, I use basic phonetic orthography.

Languages: I spoke Gbaya and fluent French before beginning my research, and learned Sango during my fieldwork. I did not learn the BaAka language, and this constrained my data collection with those BaAka individuals who do not speak Sango (in particular older women), although my assistants served as interpreters. Because I worked with

Bilo as well as BaAka informants, Sango was the more useful language to learn.

Assistants: Throughout my fieldwork I employed two assistants: Ngbongo Yves from Bayanga, and Matofi Fernand from Mossapoula. In addition, I hired two other Bayanga residents to conduct surveys: Ndombe Blaise for a neighborhood bushmeat market survey, and Bopokina Elbert for a public market survey.

Informant compensation: The issue of compensation was problematic throughout my fieldwork. In particular, I did not want to provide material or financial rewards that would encourage individuals to hunt more than they might otherwise. Therefore, I did not provide daily rewards, but several times during the course of my fieldwork purchased clothes and shoes for informants to thank them for their assistance. With respect to Bayanga snare hunting, my informants were the 16 individual hunters that I accompanied. With respect to Mossapoula net hunting, my informants were all 246 adult and adolescent BaAka residents, including those who rarely or never net hunted.

"The project": Throughout the dissertation I use this term to refer to the integrated conservation and development project described in Chapter 3. The project is administered by the World Wildlife Fund, is headquartered in Bayanga, and manages the Dzanga-Sangha Special Reserve and Dzanga-Ndoki National Park.

"The logging company": I use this term to refer to the sawmill located in Bayanga. Since 1972 three different logging companies--Slovenia Bois, Sangha Bois, and Sylvicole de Bayanga--have used this sawmill to exploit timber in the Bayanga region (see Chapter 3).

CFA francs: The currency of the Central African Republic is the Communauté Financière Africaine (CFA) franc, pegged at an exchange rate of 1 French franc = 50 CFA francs, or \$US1 $\approx$ 290 CFA francs, until January 1994. At that time the CFA franc was devalued to a new pegged exchange rate of 1 French franc = 100 CFA francs, or \$US1 $\approx$ 580 CFA francs. See Chapter 3 for a discussion of this currency devaluation.

CHAPTER 2 CULTURAL ECOLOGY, CONSERVATION, DEVELOPMENT AND HUNTING

This chapter begins by examining the theoretical context for the research within the fields of geography and anthropology, and particularly in the field of cultural ecology. The chapter in turn relates the research to the literature on biodiversity conservation, socioeconomic development, and efforts to integrate the two. The concluding section examines the relations between hunting on one hand, and both conservation and development on the other, in case studies across the tropics.

Cultural Ecology

This section reviews the development of the field of cultural ecology, particularly through the work of Carl Sauer and Julian Steward. Cultural ecology is further described by examining other research in the field.

Cultural ecology integrates geography's people/environment tradition with anthropology and ecology (Figure 2.1). The resulting theoretical framework considers the systemic interdependency between society and nature. People affect the environment and natural ecosystems by appropriating natural resources and integrating them into

production processes--whether at the household, community, or global levels. The natural environment in turn affects social structures and culture as well as subsistence and economic production systems.

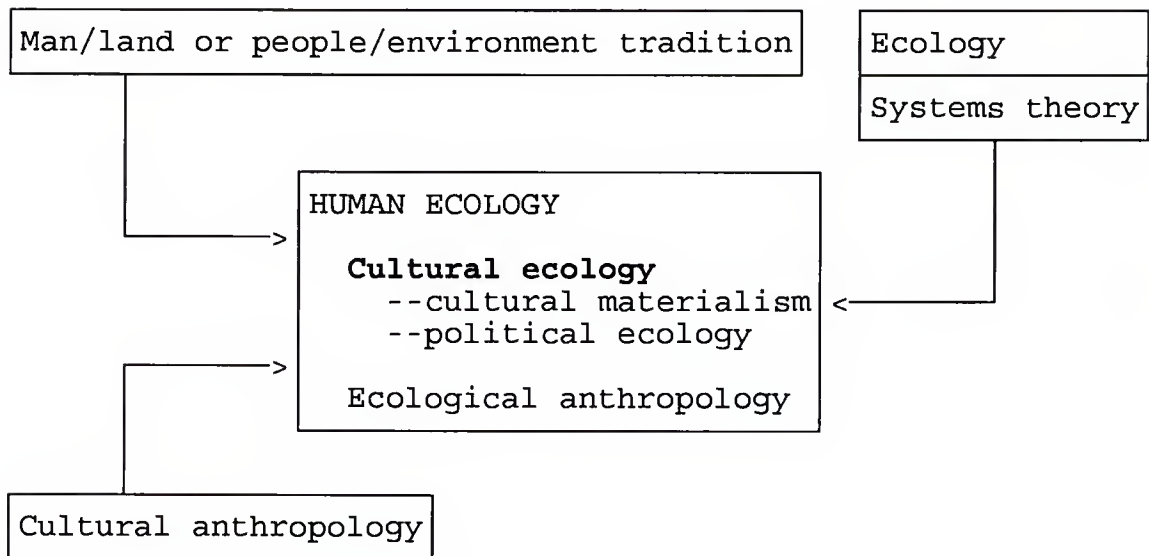


Figure 2.1: Theory in Geography and Anthropology

Note: The following components of this figure are described in greater detail below: human ecology, systems theory, ecological anthropology, cultural materialism, and political ecology.

The Origins of Cultural Ecology

The fathers of cultural ecology are the geographer Carl Sauer and the anthropologist Julian Steward.

Carl Sauer

Carl Sauer introduced the concept of culture to geography in the United States, by defining human geography as cultural history (Leighly, 1976). He saw landscape as a cultural text (Cosgrove and Jackson, 1987): "[c]ulture is

the agent, the natural area is the medium, and the cultural landscape the result" (Sauer, 1925, p. 46). Thus, humans transform natural landscapes into cultural landscapes through the action of cultural forms such as population and settlement patterns, land utilization systems, subsistence systems, and communication systems (Parker, 1981; Sauer, 1941a; 1944; 1962a; 1963a; 1963b).

Sauer set the stage for the development of cultural ecology. Most importantly, he described landscape as an association of physical and cultural forms; a changing, living scene where human activities unfold. He described relationships between resources in the environment and cultural forms. He emphasized the impacts of humans on the environment, and the influences of the environment on human activities (Sauer, 1925). For example, humans alter habitats through settlement and agriculture, and they affect particular species through domestication, dispersal, and extinction (Sauer, 1941a; 1963b). At the same time, humans adapt to the physical environment by organizing their lives around the natural resources that their skills and values identify (Gade, 1988; Sauer, 1941b; 1962a, 1962b).

Julian Steward

The anthropologist Julian Steward founded the field of cultural ecology by integrating natural systems and cultural systems into a single analytical framework. The framework's three essential components are resources, technology, and

labor. Resources are determined by culture: only human knowledge and technology make resources accessible (Murphy, 1977). Technology is a cultural trait, while the application of labor is determined by cultural elements including economic arrangements, social organization, and demography (Orlove, 1980).

Based on these components, cultural ecology addresses four principal topics: 1) the relations between the environment and exploitation or production technologies; 2) the behavior patterns resulting from appropriation and production systems in a particular area using particular technologies; 3) the effects of these behavior patterns on other aspects of culture; and 4) the impacts on culture and the physical environment of relations with other ethnic groups and external institutions (Steward, 1955; 1968). Cultures and social structures thus adapt not only to the physical environment, but also to the social environment.

Steward defined a "culture core" as the central causal mechanism influencing other aspects of culture. This culture core included the cultural features most closely connected to exploiting the environment, namely those associated with subsistence systems and economic arrangements (Moran, 1982). The environment only influences the culture core, while more peripheral aspects of culture and social organization including political and religious

patterns are subject to autonomous processes of cultural history (Murphy and Steward, 1956; Steward, 1950; 1955).

Cultural Ecology in Theory

Cultural ecology developed in opposition to environmental determinism, which emphasizes the empirical physical environment as the primary factor that determines human behavior and culture in general (Johnston, 1986; Nugent, 1981). Instead, cultural ecology favors Franz Boas' possibilism, in which the environment defines a set of opportunities and limits among which people make choices to attain goals (Brookfield, 1969; Moran, 1982). Cultural ecology follows geography's people/environment or man/land tradition, within the broader field of human ecology (Ackerman, 1963; Kates et al., 1990; Stoddart, 1987).

Human ecology

Human ecology developed in the early 1900s among sociologists who borrowed the ecosystem concept from biologists to describe the social system as a human ecosystem in which humans organize to maintain themselves in a given environment. An ecosystem is a set of organisms within a physical environment that has spatial dimensions. Ecology is the study of the biological, physical, and human components in an ecosystem, and of their interactions through energy flows and nutrient cycles (Kormody, 1974; Odum, 1975).

Human ecology is the process of forming viable relations between population and environment. The emphasis is on individuals and populations as biological entities profoundly modified by culture. These entities affect and are affected by the environment and each other. The environment includes natural and human-modified biological and physical elements as well as the cultures of peoples in adjacent areas and beyond: the components impinge on one another (Hawley, 1986). In the form of institutional systems such as market and administrative forces, production systems, and pressure groups, culture mediates between humans and the biophysical environment (Barrows, 1923; Carlstein, 1982; Smith and Reeves, 1989). Thus settlement patterns and subsistence strategies reflect social behavior, technology, resource opportunities and limitations, as well as external and internal stimuli (Butzer, 1982; Helm, 1962; Morrill, 1987; Porter, 1978). Some theorists describe human ecology simply as human behavior: culture is therefore the ecological equivalent of animal behavior (Bennett, 1990; Rappaport, 1984; Vayda and Rappaport, 1968).

Systems theory

Systems theory, like ecology, provides a method for the holistic analysis of human situations, rather than a theory that permits rigorous problem selection (Brookfield, 1982; Ellen, 1982). Generally speaking, a system is a framework for describing and analyzing a complex array of unlike

variables that interact through connectivity, mutual causality, and feedback (Butzer, 1990; Morren, 1986). Systems analysis emphasizes the functions and interchanges of component parts, through flows of energy, materials, and information that can be quantified (Micklin, 1984; Odum, 1983; Rambo, 1982a; 1983; Sponsel, 1989). All interactions are interdependent (Butzer, 1989). Systems theory enhances the ecological framework of cultural ecology analysis because it integrates environmental and human variables (Stoddart, 1965).

However, it may be impossible to quantify certain factors, particularly external factors that are significant in an open system (Butzer, 1990; Ellen, 1982). For example, socio-political and ideological factors must be included in the analysis because the environment and technology are not sufficient to explain contemporary ecosystem realities (Parker, 1981; Orlove, 1980).

Ecological anthropology

Ecological anthropology and cultural ecology both emphasize culture as a means of adapting to the environment (Headland, 1986; Jochim, 1981; Parker, 1981), and both examine the interactions of human populations with other components of the local ecosystem and with external influences (Helm, 1962; Moran, 1981a). Systems of production are important links between population dynamics,

social organization, culture, and the environment (Orlove, 1980).

However, ecological anthropologists emphasize the evolutionary nature of human adaptive strategies, including sociocultural as well as physiological responses to problems and stresses imposed by the local environment (Morren, 1986; Orlove, 1980; Parker, 1981). Alternatives can be compared, and overall success in human adaptability can therefore be measured according to demographic, energetic, and nutritional criteria (Moran, 1982).

Adaptive strategies include demographic shifts through migration and changes in settlement patterns, socioeconomic relations with other groups through trade links, and culture traits like technology (Gross et al., 1979; Moran, 1982; Morren, 1986; Tanaka, 1980). In addition, current adaptive strategies are strongly influenced by regional level factors including the goals of national and international actors regarding production, conservation, and development at the regional scale (Moran, 1981a).

Cultural ecology

Like human ecology, cultural ecology is defined generally as the systemic relations between society or social systems on the one hand, and nature or ecosystems on the other (Butzer, 1989; Grossman, 1977; Moran, 1981a; Turner, 1989). More specifically, cultural ecology refers to the adaptation of human society to the local environment

through the flexible agent of culture (Bahuchet, 1985b; Baksh, 1984; Butzer, 1990; Clarkson, 1968; Knight, 1992). The local environment includes not only natural resources, but also other human groups that influence adaptation (Barth, 1969; Campbell, 1983; Netting, 1968; Sponsel, 1986).

Carl Sauer examined the results of human-environment interactions visible in landscapes (Parker, 1981). Cultural ecologists more recently have focused on the processes of change. They argue that culture does not simply adapt to environmental constraints or changing environmental conditions: feedback processes between culture, technology and nature alter the natural environment as well as the human environment (Bargatsky, 1984; Bennett, 1976; Headland, 1986; Nowicki, 1985). People alter the habitat to make it a more suitable place to live, while also making themselves more suitable to live in that habitat (Denevan and Schwerin, 1978). Cultural ecology therefore describes the human use of resources, and the human appropriation of nature (Bargatsky, 1984).

Steward's cultural ecology has been criticized for treating culture and environment as separate and opposed entities, lacking the concept of dynamic mutually interacting processes (Moran, 1990). In the 1960s cultural ecologists refocused the field on the ecosystem as a unit of analysis (Ellen, 1988). Nature and culture came to be seen as two interlocking subsystems of a larger system (Figure

2.2) in which relations among components are circular (Bennett and Chorley, 1978; Mikesell, 1978; Rambo, 1982). Within the larger system, cultural ecology emphasizes the predominant role of culture in mediating change and governing feedback relationships (Sponsel, 1980). Nevertheless, the ecosystem interacts with every component of the culture system, and determines a set of freedoms and constraints within which individuals exercise choice (Parker, 1981; Sponsel, 1986).

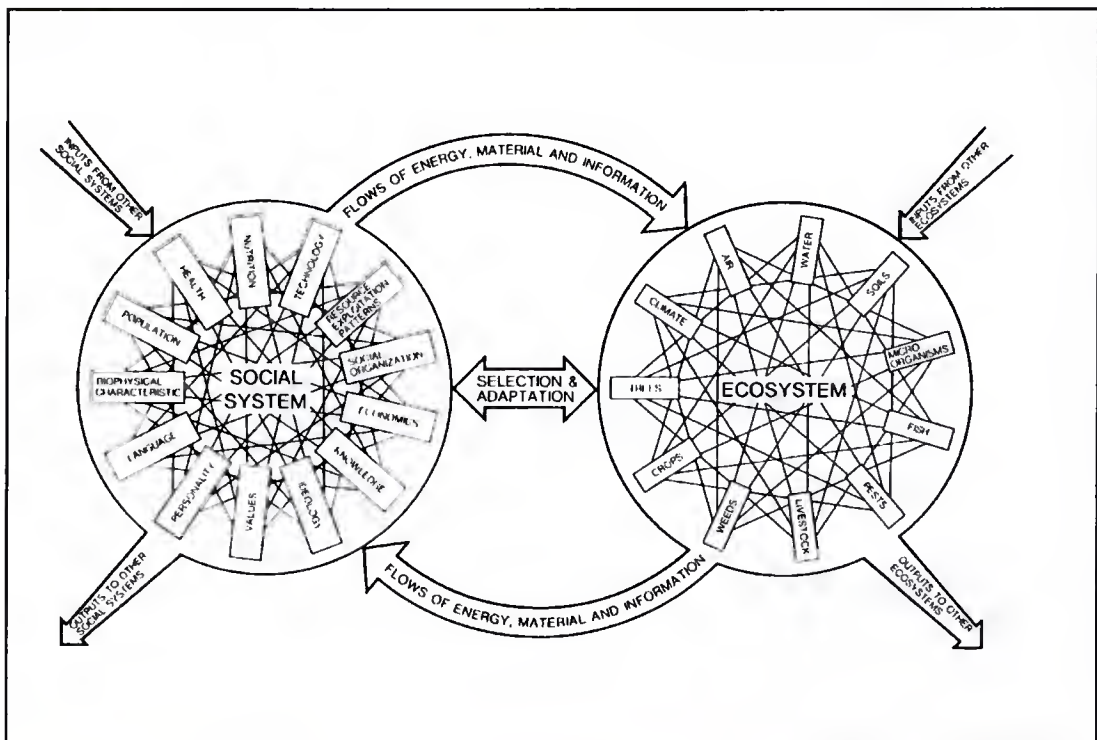


Figure 2.2: A Systems Model of Human Ecology

Source: Rambo, 1983, p. 26. Reprinted with permission of the author, A.T. Rambo.

The ecosystem concept has been criticized for neglecting the critical role of external factors such as larger economic and political systems, as well as the historical background of contemporary environmental circumstances. Defining ecosystem boundaries is also problematic. Furthermore, ecosystem analyses tend to emphasize long-term homeostasis and ignore changes taking place in local ecosystems. Finally, they overlook diversity and differentiation within local groups or populations, and the options people have in adjusting to change (Lees and Bates, 1990; Moran, 1990; Orlove, 1980).

Cultural Ecology in Practice

Cultural ecology has addressed a variety of topics in a wide range of human societies. Given the critiques described above, cultural ecologists have used a variety of methods that identify particular subsystems or problems for analysis, or that emphasize particular components of the human/environment system.

Cultural materialism. Cultural materialism gives primacy to the technological and economic components of the cultural system, as they relate to modes of production and reproduction (Abruzzi, 1980; Micklin, 1984; Sponsel, 1983). These elements of social organization and culture are practical adaptations permitting a particular population to exploit its environment successfully (Harris, 1966; 1974;

1977). Like ecological anthropology, this field focuses on population as a unit, and on biological concepts such as carrying capacity, nutrient flows and energy cycling (Orlove, 1980; Rappaport, 1984).

Political ecology. Political ecology emphasizes the influence of political and social ideologies as well as economic processes on the interactions of society and the environment through the organization of labor, space, and resources in the system of production. Exogenous political and economic forces, as well as the internal structure of society governing access to resources and modes of production, condition local ecosystem-human system interactions (Bassett, 1986; 1988; Bell and Roberts, 1991; Hecht and Cockburn, 1989; Hyndman, 1994; Knight, 1992; Pickles and Watts, 1992; Schmink and Wood, 1987; Watts, 1989).

Subsistence economies

Because of the practical difficulties involved in analyzing all the components of ecosystem-human system relationships, cultural ecologists have focused on relatively small, isolated, and homogeneous systems in which cultural institutions tend to be dominated by subsistence activities (Fosberg, 1976; Headland, 1986; Mikesell, 1978; Porter, 1978). Although relations with the physical environment are particularly direct, impacts on the environment are minimal (Bennett, 1976; Rambo, 1983).

Subsistence systems represent a means of regulating energy flows between the human population and the ecosystem (Nietschmann, 1984). Research in cultural ecology describes how these societies exploit and alter their environment through hunting, gathering, fishing, and agriculture (Bahuchet, 1972; 1978; 1979a; 1979b; 1985b; Dornstreich, 1977; Marks, 1976; Nietschmann, 1971; 1973; Smole, 1962; Vickers, 1979). Cultural ecology further examines cultural adaptation to environmental constraints, for example to argue that the lack of animal protein causes people to establish complex food prohibitions to protect certain game animals (Ross, 1978). Shifting agriculture also represents an adaptation to environmental constraints such as poor soil fertility, and abundant weeds and pests, as well as to socioeconomic constraints such as scarce labor and inefficient technology (Denevan, 1978). Finally, ecological change can induce social change: the depletion of forest resources results in more intensive exploitation, and the dispersal of human settlements (Baksh, 1984; 1985).

Many subsistence societies in tropical forests adapt to their environment by maintaining trading relationships with neighboring societies. In its simplest manifestation, one group exploits forest resources such as wild animals, while the other cultivates food crops, and the meat-for-starch exchange provides both groups with both products (Headland 1986; 1988; J. Peterson, 1977; 1978a; 1981; Terashima,

1986). Thus, dynamic relations with neighboring groups are key factors influencing settlement patterns, mobility, and even hunting techniques (Bahuchet, 1978; Endicott, 1979; 1984; Harako, 1981; Hoffman, 1988; Rambo, 1979a; 1982b). Recent studies argue that the choice of foraging strategy is an outcome of social and economic pressure by neighboring groups (Eder, 1988b; Sellato, 1994).

Developing economies

In the case of more complex human-environment systems with links to external political and economic forces, researchers have focused on particular subsystems, in particular agricultural subsystems (Brookfield, 1969; Clarkson, 1968; Netting, 1968; 1986; Rambo, 1982a). The systemic relationships incorporated in the analysis have expanded to include not only the natural environment and subsistence production, but also commodity production, the social relations of production, cultural values, and political and economic forces (Grossman, 1984). Others emphasize the "human ecosystem" comprising four components linked by systems of production: population dynamics, social organization, culture, and environment (Headland, 1986). Finally, cultural ecologists have studied cultural methods and institutions for regulating and managing natural resources, such as fisheries, wildlife, forests, etc. (Nietschmann, 1973; 1984).

Alternatively, one may begin with a particular human-environment problem, and contextualize relations within progressively wider or denser contexts (Vayda, 1983). Similarly, Lees and Bates (1990) advocate beginning with a specific environmental event and analyzing environmental change and human behavior in response to this event. These methods apply cultural ecology by examining the effects of economic and social organization on the ecosystem, and the impact of environmental change on socioeconomic systems. But they do not depend on predetermined units of analysis or specific system boundaries.

Cultural ecology themes

As described above, cultural ecologists analyze the food base, activity patterns, group composition, resource availability, relations with other groups, and change over time in all these variables. Food production is considered to be the primary human/environment nexus, and cultural ecologists emphasize the coevolution of subsistence strategies and certain features of the environment (Bargatsky, 1984; Ellen, 1988; Knight, 1992; Mikesell, 1978). They identify environmental constraints and analyze patterns of social adaptation to cope with change in ecological and social systems (Butzer, 1990; Durham, 1976). For example, in the context of Brazil's Transamazon settlement scheme, which has significantly altered the tropical forest, colonists must adapt to both ecological

constraints such as low soil productivity as well as socioeconomic constraints such as limited access to transportation and markets (Denevan, 1973; 1989; Smith, 1976a).

In addition to local environmental and socioeconomic constraints, institutions at the regional, national, and international levels determine the nature of interactions between people and the environment (Marks, 1989; Moran, 1979; 1993; Riddell, 1988). Thus the growth of extractive industries and commercialization in Brazil has in many places replaced Indian culture with caboclo culture, as people opportunistically respond to new resources and new environmental and socioeconomic constraints and opportunities. They adapt through technological, institutional and organizational change (Dove, 1993b; 1994; Hardesty, 1986; Kates, 1987; Parker, 1981).

New economic systems thus offer new opportunities, subject to new constraints such as limited land availability and rising population density. Subsistence societies may exploit new resources, adopt cash crops, and engage in non-agricultural activities (Denevan and Schwerin, 1978; Grossman, 1981; 1984; Nietschmann, 1972; 1973). Ecological systems facilitate as well as limit human action, while resource exploitation using particular technologies imposes short-term and long-term effects on social and natural systems (Smith, 1976a).

Cultural ecologists are also interested in traditional resource use and management institutions as potential models for development schemes in the Third World (Bennett and Dahlberg, 1990; Butzer, 1989; Eden, 1978; Marks, 1984; Nowicki, 1985; Sponsel, 1985; 1986). Other general topics include the following: environmental and regional planning, environmental constraints to development, the relations between environmental potentials and economic opportunities, the consequences of shifting from a subsistence to a market economy, sedentarization, intensification of production, land use and tenure, and tourism studies (Bennett, 1976; Ellen, 1988; Hardesty, 1986; Knight, 1992; Mabogunje, 1984; Mikesell, 1978; Murphy and Steward, 1956; Porter, 1978; Rambo, 1982a). The following chapters address many of these topics through a case study of wildlife exploitation, linking hunting in the Bayanga region to wider ecosystem and human system causes and effects.

Conservation and Development

The relationship between hunting and the ecosystem is particularly important with respect to biodiversity conservation: hunting directly reduces wildlife populations, and excessive hunting may cause their extinction. At the same time, the relationship between hunting and the human system is particularly important with respect to socioeconomic development: hunting provides

subsistence and economic resources to local populations. Hunting therefore connects the two systems and reveals their interdependencies. In order to sustain both systems, biodiversity conservation and socioeconomic development must be integrated, for example through the sustainable exploitation of wildlife, and sustainable development for the human population.

Biodiversity Conservation

The concept "biodiversity conservation" has many meanings. Biodiversity refers to biological variability and abundance at several scales: genes, species, communities or ecosystems (McNeely, 1988; Reid and Miller, 1989; WRI et al., 1992). Biodiversity conservation may therefore seek to preserve particular ecosystem components (genes, species, populations) as well as the patterns and processes that complete ecosystems represent (Ehrlich and Wilson, 1991; Noss, 1990; Reid and Miller, 1989).

In its strictest sense, conservation seeks to preserve natural ecosystems free of human intervention, manipulation, or management. Thus protected areas prohibit traditional development activities such as agriculture, resource extraction, and human settlement. Strict preservationists emphasize the moral and aesthetic values of protecting nature for its own sake, and the ecological services that

protected areas provide to society (Callicott, 1990; Lund, 1980; Nash, 1967).

However, conservationists began seeking economic justifications for conservation efforts for two reasons. First, conservation imposes economic costs on local people in the form of land and resource alienation, together with crop destruction and threats to personal safety from wildlife (McNeely and Miller, 1984). Second, conservation imposes economic costs on the nation in the form of management expenses and lost opportunities to use the land in more economically productive ways. At the local and national levels, conservation competes with other forms of land use, and the alternatives are usually evaluated on the basis of short-term economic costs and benefits (Dixon and Sherman, 1990; O'Riordan, 1988; Pullan, 1983b; Western, 1984a; 1984b). The economic incentives to exploit protected area resources are strong, while protected area managers lack the resources and the political commitment to prevent destructive human activities.

The extreme "use it or lose it" view argues that unless wildlife is economically valuable, it will be replaced by more productive land use systems (Freese, 1994; Kock, 1995; Luxmoore, 1989). Many conservationists are therefore seeking viable methods for the sustainable use of wildlife, methods that derive economic benefits without exterminating species or degrading ecosystems.

Socioeconomic Development

"Development", like "conservation" is a term with many meanings. Development implies the improvement or fulfillment of potential (Daly, 1990b). Development can have political or ethical implications, in terms of achieving self-sufficiency and self-determination (Dasmann, 1984). But it is most often associated with improving economic conditions according to criteria such as income, efficiency, and productivity (Berger, 1992; Bodley, 1988; Foresta, 1991). Thus the primary objective for many development efforts has been to promote economic growth by increasing the productivity of traditional economic and subsistence activities, or by introducing new activities (Burbridge, 1987). Development is achieved primarily through technological and institutional innovation in food production, resource extraction, industrial production, and other economic sectors (Barbier, 1987).

Traditional development efforts therefore focus on transforming natural ecosystems into more productive artificial ecosystems managed by humans. In the case of tropical forests the process has been extraction of available resources through logging and mining, and conversion to more productive land uses such as agriculture or ranching. But these approaches have been severely criticized from three perspectives:

1) Some bemoan economic growth without development for the rural poor (Berger, 1992; Chambers, 1983; Independent Commission, 1980; Lakshmanan, 1982; O'Riordan, 1989; Redclift, 1984; 1987; Schumacher, 1973).

2) Others argue that generating short-term economic benefits imposes severe long-term economic costs by degrading the environment: tropical forests are particularly fragile ecosystems (Denevan, 1989; Eden, 1978; Nicholaides et al., 1985; N. Smith, 1976a; 1981).

3) Finally, proponents of "limits to growth" theories argue that natural resources are limited, and the environment's carrying capacity will soon be reached, given current consumption patterns and population growth (Brookfield, 1988; Daly, 1990a; 1990b; Fearnside, 1986; Hardin, 1986).

"Sustainable development" was widely promoted in the 1980s as a means of addressing problems of poverty, environmental degradation, and skewed resource distributions that economic growth models have ignored (Barbier, 1987; Fearnside, 1983; Lele, 1991; O'Riordan, 1989; Redclift, 1991; WCED, 1987). Most definitions of sustainable development emphasize the maintenance of ecological and economic viability through time. Development is economically viable if economic benefits equal or exceed economic costs. Development is ecologically viable if it does not deplete biophysical resources or degrade ecosystems

(Brookfield, 1990; Goldman, 1995; Tisdell, 1988; Wilbanks, 1994).

Sustainable development promotes small-scale production systems and appropriate technologies that minimize environmental and sociocultural impacts (Browder, 1989; Schumacher, 1973; Trainer, 1990). Geographers and anthropologists in particular stress the importance of adapting development activities to local economic, social, and ecological conditions (Clay, 1988; Mabogunje, 1980; Redclift, 1987; Richards, 1985; Watts, 1987; 1989). New approaches to development therefore focus on the sustainable use of natural resources and ecosystems, recognizing that the conservation and management of natural resources is essential to successful long-term socioeconomic development.

Integration of Conservation and Development

In turning to the sustainable exploitation of wildlife and sustainable development respectively, development and conservation practitioners have increasingly recognized the mutual interdependence of their objectives (Lele, 1991). Development depends on careful management of natural resources, while conservation is not possible unless development reduces pressure on natural resources. Development can provide additional resources for environmental protection, but environmental degradation

undermines development goals (McNeely, 1988; Whitaker, 1986; World Bank, 1992).

Some researchers even argue that human cultural diversity is a component of biodiversity, and that humans are an integral part of nature (Bennett, 1975; Callicott, 1990). In particular, indigenous peoples are described as "ecosystem people" who live within the ecosystem in a sustainable manner (COICA, 1989; Colchester, 1992; International Alliance, 1992; Klee, 1980; O'Connor, 1994; Oldfield and Alcorn, 1991). Humans have helped to create and maintain most tropical forest ecosystems; therefore to exclude humans in the name of conservation will fundamentally alter ecosystem processes and biodiversity (Bahuchet, 1993; Bailey et al., 1990; Balée, 1989; Kormody, 1974; McNeely et al., 1990). Restricting people's access to land and natural resources upon which they have historically depended can also be disastrous for human societies.

Thus policymakers began to emphasize the role of parks in regional and national development (MacKinnon et al., 1986; McNeely and Miller, 1984; Pullan, 1983a), and the potential for integrating production systems with the environment (Brookfield, 1988). Wildlife, because of its economic value, becomes a development resource (Abel and Blaikie, 1986; CAR, 1992; Dalal-Clayton, 1988; Pullan, 1983b). But it will only remain a resource so long as exploitation is not excessive.

In 1980, three of the world's largest conservation agencies¹ produced the World Conservation Strategy (WCS), which defines three objectives for conservation: to maintain essential ecological processes and life-support systems; to maintain genetic diversity; and to ensure the sustainable utilization of species and ecosystems which support rural communities and major industries (IUCN, 1980). The WCS recognizes that a major threat to conservation is underdevelopment, and argues that conservation projects must provide for economic growth to improve the economic status and the quality of life for rural people (Erskine, 1985; Halle, 1985). It also encourages development projects to invent and apply methods that are ecologically sound, and that conserve the living resources essential for human survival and well-being (Allen, 1980; Talbot, 1984).

Efforts to integrate conservation and development have adopted a variety of theoretical and practical models. Conservationists have begun to promote the integration of conservation efforts with development activities that benefit local people and the national economy (Eltringham, 1984; Freese, 1986; Kundacli, 1984). At the local level, conservation projects recognize the legitimate rights of rural people to utilize local natural resources (West and Brechin, 1990). Furthermore, conservationists increasingly

¹The International Union for the Conservation of Nature (IUCN), in cooperation with the United Nations Environmental Programme (UNEP) and the World Wide Fund for Nature (WWF).

seek the cooperation and support of local communities, as well as their active participation in conservation management (Barrow et al., 1993a; 1993b; Brown and Singer, 1990; Clay, 1985; Gibson and Marks, 1995; Kiss, 1990; Western and Henry, 1979; Western and Wright, 1994). At the national level, conservation projects promote the sustainable exploitation of natural resources, through non-consumptive (Caro, 1986; Lusigi, 1981; 1988; McIvor, 1989; World Bank, 1990) as well as consumptive forms of wildlife exploitation (Abel and Blaikie, 1986; Berry, 1986; Dalal-Clayton, 1988; Lewis et al., 1990; Luxmoore, 1985; Metcalfe, 1994).

Integrated conservation and development projects (ICDPs) combine core protection areas for tourism and research with buffer zones or multiple use areas for sustainable subsistence and economic activities (Wells et al., 1992). The projects promote socioeconomic development by providing health and education services, as well as by introducing new economic opportunities and activities in order to reduce local dependence on wildlife resources. At the same time they promote biodiversity conservation by protecting parks and restricting traditional economic activities to ecologically sustainable levels and methods (Brown and Singer, 1990; Du Toit, 1985; Ruitenbeek, 1992; Sayer, 1987; Sharma, 1990; Western, 1984b; Zube and Busch, 1990).

In part ICDPs are a concession by international conservation groups that police measures alone are not sufficient to protect wildlife: in the long run local poverty and population growth will overwhelm park authorities' resources and commitment to conservation. At the same time, ICDPs represent the hope that sustainable exploitation of natural resources by local people is possible, i.e., that careful management can generate short-term benefits and long-term economic growth without depleting the resource base. A proliferation of publications argue that conservation and development are compatible (BSP, 1993; Clad, 1984; Cleaver and Schreiber, 1994; IUCN, 1980; IUCN et al., 1991; Ledec and Goodland, 1988; McNeely and Miller, 1984; Oldfield and Alcorn, 1991; WCED, 1987). However, evidence of success in the field is scarce, and arguments to the contrary are numerous (Browder, 1990; 1992; Mares and Ojeda, 1984; Mordi, 1991; Redford, 1992; Redford and Sanderson, 1992; Robinson and Redford, 1994b; Struhsaker, 1990).

A comparative assessment of ICDPs across the tropics finds that few provide viable alternatives to extensive resource utilization practices, and they have difficulty producing and distributing benefits from conservation. The emphasis on local participation can lead ICDPs to respond increasingly to short-term needs at the expense of long-term issues. Although ICDPs encourage local participation and

empowerment, local people's needs and interests may include "unacceptable" activities that overexploit or degrade the environment (Brandon and Wells, 1992; Wells and Brandon, 1993).

Some critics argue that rural development components are primarily a means to reduce tensions between parks and local people, but do not attempt to provide sustainable livelihood alternatives (Ghimere, 1991; Jeanrenaud, 1992). According to others, ICDPs too often emphasize the promotion of income generating activities and the provision of social services, while neglecting resource management objectives (Durbin and Ralambo, 1994). These problems can be addressed in the implementation of specific projects.

However, more serious criticisms of ICDPs suggest fundamental contradictions between conservation and development objectives. Some development activities directly undermine conservation objectives: roads improve access for illegal woodcutters (Stocking and Perkin, 1992). In addition, agricultural extension can make rural areas more appealing, and may draw additional people near protected areas, thus increasing the pressure on wildlife resources (Oates, 1995; Southgate and Clark, 1993). Immigration, wealth accumulation and population growth limit the positive effects of development for local populations, while even limited exploitation of wildlife resources produces biotic impoverishment (Kremen et al., 1994).

Furthermore, in the long term the sustainable exploitation of wildlife cannot support continuously rising human populations and needs with a wildlife resource base that fluctuates with environmental conditions and whose habitat is declining (Barrett and Arcese, 1995).

The ICDP model assumes that by providing economic benefits and alternative economic activities, local people will alter their behavior with respect to wildlife. Evidence suggests that this assumption is erroneous. Many rural households have surplus labor and low opportunity costs for their time. Therefore they can adopt new activities promoted by the ICDP without abandoning those activities that the ICDP seeks to eliminate, such as poaching (Barrett and Arcese, 1995; Southgate and Clark, 1993). For most individuals, the benefits they receive from the ICDP are less than the costs they incur. In addition, ICDPs generally provide public services to communities as a whole, and cannot exclude particular individuals who continue to poach wildlife (Gibson and Marks, 1995).

Finally, the link between indigenous peoples and biodiversity conservation is severely strained under market pressures. Indigenous peoples have the same capacities, needs, and desires to overexploit the environment as do other peoples. Given more efficient technologies, growing populations, and external markets for forest products, resource exploitation by indigenous peoples no longer is

compatible with biodiversity conservation (Browder, 1992; Gray, 1990; Marks, 1989; Plotkin and Famolare, 1992; Redford, 1991; Redford and Sanderson, 1992; Robinson and Redford, 1994b). These peoples have numerous economic incentives to "mine" natural resources (Barbier et al., 1994; R. Smith, 1981; Southgate and Clark, 1993).

Furthermore, development based on forest product extraction,² if it is successful in creating markets and raising prices, inevitably fosters overexploitation as external political and economic forces intercede (Dove, 1993a; Hanson, 1992; Jeanrenaud, 1992; Ryan, 1991). Others argue that, because of political and social forces for wealth accumulation, and the lack of understanding of complex natural systems, resources are inevitably overexploited, and sustainable use is impossible (Ludwig et al., 1993). Thus wildlife is in a Catch-22 position: if it has no economic value, alternative land uses will eliminate wildlife habitat; yet if wildlife is valuable, overexploitation is inevitable (Prescott-Allen, 1982).

In general, ICDPs require serious local and national political commitment, conducive legislation, appropriate institutions, low or stable population densities, widespread use of traditional or appropriate technologies for resource extraction, and effective protected area management--a set of conditions unlikely to be found anywhere (Wells et al.,

²For example, extractive reserves in the Amazon.

1992). Notwithstanding these critiques, numerous efforts to integrate development and conservation are underway across the tropics, because of the local, national, and international support for both biodiversity conservation and socioeconomic development in tropical forests.

Conservation, Development and Wildlife: The Role of Hunting

Hunting is an important subsistence and economic activity for forest residents throughout the tropics. Most forest inhabitants pursue a mixed subsistence and economic strategy that combines hunting with cultivation, commercial extraction of forest products, wage labor, etc.

Hunting Methods

Traditional³ hunting technologies are often very closely adapted to particular ecological conditions: the desired prey species, the availability of materials for making weapons, the forest structure, the season, and even the time of day (Bahuchet, 1988). Hunting methods also depend on the particular historical and cultural context: peoples in similar environments adopt different technologies because of their contacts with other groups (Bahuchet, 1978). Finally, the economic and social environment determines which technologies among those available are

³Many hunting methods that date back to pre-European contact or pre-westernization times are still used today.

selected or commonly used: accessibility of technology, skill and knowledge, human settlement or hunting group size, subsistence versus commercial objectives, as well as personal preference and prestige.⁴ As these cultural and environmental conditions evolve over time, the role of hunting in turn continually changes.

Some animals, such as tortoises, are captured by hand. Clubs are used for killing creatures that could be captured by hand, that are trapped in nets, or that are cornered by dogs. Groups of hunters with spears, sometimes working with dogs, hunt large game including elephants (Bahuchet, 1988; Brosius, 1991; Harako, 1976; Sandbukt, 1988; Terashima, 1983; Vallois and Marquer, 1976).

Snares are widely used, and are extremely variable both in terms of the prey captured and the particular techniques employed. Pit traps, with or without sharpened and poisoned stakes in the bottom, are used to capture large terrestrial animals such as pigs and okapi. Gravity traps employ a spear or log that falls when an animal triggers the trap.

⁴An important debate in the literature on Zaïre Pygmies discusses the reasons for the reliance on nets versus bows and arrows by neighboring groups in the Ituri forest. Both ecological and socio-economic explanations are proposed. Ecological explanations focus on the structure of the forest (Roscoe, 1990), the availability of plants used for making nets (Bahuchet, 1989; Harako, 1976), or the density of wildlife populations (Milton, 1985; Terashima, 1983). Socio-economic explanations emphasize the importance of commercial meat hunting and the value of women's labor (Bailey and Aunger, 1989; Hayden, 1981; Wilkie and Curran, 1991), or population densities and relations with neighboring farmers (Abruzzi, 1979; 1980).

Noose snares can be used for virtually any bird or animal, and are placed on terrestrial or arboreal animal trails. Alternatively, baits can be used to attract the prey. Nylon and cable wire are widely used because they are stronger and last longer than cord made of natural fibers (Schultz, 1986). Snares are often set around crops, both to protect farms from wildlife depredations and to acquire meat from animals attracted by the crops (Bahuchet and de Garine, 1990; Carpaneto and Germi, 1992; Orejuela, 1992). But snares are also set out in the forest, from 20 to as many as 500 in a snare line that is regularly checked (Almquist, 1992; Hewlett, 1977; Infield, 1988; Wilson and Wilson, 1991a). In some cases hunters build long fences with gaps in them, and place noose or gravity snares in the gaps (Dwyer, 1990; Sandbukt, 1988).

A variety of projectile weapons are used for killing terrestrial and arboreal animals of all sizes at a distance: the bow and arrow, the crossbow, and the blowgun. Hunters often apply poison to the arrows or darts. A single hunter may search for game tracks and sounds, or hide in a blind near a fruiting tree or an animal trail. Hunters also call animals to bring them within range (Demesse, 1980; Harako, 1976; Harner, 1972; Stearman, 1989a). In Latin America groups of hunters hunt together when a herd of white-lipped peccaries has been sighted. The Efe and the Boyela in Zaïre conduct group bow hunts: a group of hunters forms a large

semi-circle, and a group of beaters drives game toward the hunters (Sato, 1983; Terashima, 1983).

Finally, nets are a specialized hunting technology used in African savannas and forests (Almquist, 1992; Arom and Thomas, 1974; Berry et al., 1986; Demesse, 1980; Koch, 1968; Newman, 1970; Sato, 1983; Sévy, 1972; Tanno, 1981; Terashima, 1980), and also in India to hunt monkeys (Sinha, 1972; Williams, 1969). The Aka and Mbuti probably adopted nets from neighboring farming peoples, but few agriculturalists use nets today. Mbuti hunting nets measure approximately 1.2 meters high and from 30 to 100 meters long. They are normally used by a group of men and women hunting together: several nets are joined together to form a large semi-circle or a closed circle, and beaters drive animals into the nets (Ichikawa, 1983). This is an efficient technology for capturing small terrestrial mammals weighing less than 20 kilograms, but larger animals are usually able to break through or leap over the nets.

Hunting methods depend not only on ecological factors, but also on the role of other economic and subsistence activities. Farmers tend to hunt near their residences, venturing out for day hunts or longer stays during periods when less agricultural labor is required. More mobile hunter-gatherers, like the Aka of CAR, the Mbuti of Zaïre, the Agta of the Philippines, or the Aché of Paraguay, often

hunt for extended periods from forest camps that can be several days' walk from roads or permanent settlements.

Across the tropics, modernization means that traditional cross-cultural diversity in hunting methods is giving way to the shotgun as an all-purpose, all-season hunting weapon. The shotgun has a greater range than traditional weapons, it is often more accurate, and heavy shot is not deflected by intervening vegetation between the hunter and the target (Hames, 1979; Rambo, 1978).

The shotgun does have limitations, including the high cost of guns and ammunition (Beckerman, 1980; Chin, 1984; Laurent, 1992; Nietschmann, 1972; Paolisso and Sackett, 1985; Saffirio and Scaglione, 1982), reliability problems with wet powder and misfiring (Yost and Kelley, 1983), and the noise of firing which scares away other game (Alvard, 1993; Baksh, 1984; Rai, 1982; Ross, 1978). There are also legal restrictions on owning guns: many countries require firearm licenses; and Malaysia, Indonesia and the Philippines have totally banned shotguns under martial law (Endicott, 1979a; Griffin, 1981; Hoffman, 1986; Morren, 1986).

Pressure on Wildlife Resources

Indigenous forest hunter-gatherers adapted to their environment by living in small, mobile, and dispersed groups. As they depleted wildlife resources in one area,

they split into smaller groups or moved their camp elsewhere (Baksh, 1985; Vickers, 1980). Forest farmers also generally lived in small dispersed settlements. The pressure on wildlife was geographically and temporally extensive, with fallows in space and time allowing wildlife populations to recover and maintain themselves despite human exploitation. These fallows resulted from a variety of cultural practices: hunting zone rotation (Almquist, 1992; Balée, 1989; Hames, 1980; 1986; Morren, 1986; Sponsel, 1980), buffer zones between antagonistic groups (De Boer, 1981; Gross, 1975; Sellato, 1994), hunting sanctuaries (Turnbull, 1983), seasonal trekking (Moran, 1981b), and seasonal hunting (Bahuchet, 1985b; Dwyer, 1982; Eder, 1988a). Traditional forest hunting was probably sustainable because of low human population density, simple technology, and subsistence-oriented production (Redford, 1991; Schmink et al., 1992; Uquillas, 1985; Vickers, 1991).⁵

These conditions rarely exist in tropical forests today. Wildlife exploitation is becoming more intensive, as both temporal and spatial fallows are decreasing: more people are hunting continuously in smaller and smaller areas. The human population in forest regions is growing, with larger and more permanent population centers (Bahuchet,

⁵However, even subsistence-level production with simple technologies may severely depress populations of certain species, for example slowly-reproducing primates (Godoy and Bawa, 1993; Peres, 1990; Redford and Robinson, 1985).

1985a; Bahuchet and Guillaume, 1979). A larger number of people, including immigrants and urban dwellers, now depend on the same wildlife resource base. Hunting is increasingly market-oriented (Seeger, 1982).

Large-scale government colonization plans in Brazil and Indonesia have encouraged landless people in high-density areas to migrate to relatively unpopulated forests. But in other countries similar population shifts are occurring without formal government incentives (Hart and Hart, 1984; Peterson, 1992a; 1992b; Wilkie, 1987a). Forests comprise an important frontier that was not exploited more intensively when there were easier and less marginal environments to exploit. Other lands are often no longer available for poor people who must farm to feed themselves. In addition, valuable products exist in forests: timber, minerals such as gold and diamonds, and animal products such as ivory, skins, and bushmeat.⁶ Technologies and capital are now available to exploit all these resources intensively.

Hunting is an important subsistence and economic adaptation that allows forest peoples to survive. But the available hunting area is declining as people migrate to forest regions, and as exploitative activities convert forest to other uses such as cattle ranches, farms, plantations; or simply degrade wildlife habitat by

⁶"Bushmeat" is a term from west Africa that refers to all meat from wild animals killed for food.

intensively extracting resources, for example through logging and mining (Griffin, 1985; 1989; Headland, 1986; Rodgers et al., 1991; Stearman, 1990). Furthermore, the international movement to preserve tropical forests is providing external funds for tropical countries to create protected areas in forests, areas which often prohibit or constrain hunting activities (Doungoubé, 1990; Nations and Hinojosa, 1989). At the same time, shifts to new technologies such as firearms and cable snares, combined with production for external markets as well as subsistence needs, all tend to increase the intensity and efficiency of hunting activities. Although few researchers have collected both socioeconomic and ecological data,⁷ it is likely that harvest rates are exceeding reproduction rates for many exploited species.

Wildlife Management Practices

Forest peoples in most cases exhibit a fatalistic attitude towards wildlife, exploiting wildlife resources as if they are unlimited. Some hunters associate hunting yields with mystical spirits: if yields decline it is because the spirits have not been properly treated, not because people have overhunted (Bulmer, 1982; Dwyer, 1982).

⁷The exception is a research team in Peru which has collected abundance, productivity, and harvest rates for particular game species in a particular location (Bodmer, 1994; Bodmer et al., 1988a; 1988b; 1994; 1995).

Much indigenous knowledge of wildlife, intimate though it may be, focuses on harvesting as opposed to managing these resources. Therefore, most forest peoples do little to conserve harvests. The primary concern is for short-term yields, not for long-term conservation of wildlife (Bulmer, 1982). Hunting is usually opportunistic: any animal of any species encountered is pursued, and hunters do not discriminate by sex or age of prey, capturing females and young whenever they are available (Alvard, 1993; 1994; Hames and Vickers, 1982; Redford and Robinson, 1985).

In the past, there were always other unoccupied areas to which people could move when local resources were depleted, and permanent environmental degradation did not result from their activities (Johnson, 1989; Kaplan and Kopische, 1992). In the modern context, perhaps they lack economic alternatives and must emphasize short-term needs at the expense of long-term sustainable resource management. Alternatively, they may fail to anticipate future scarcity resulting from overexploitation because resources have always been abundant in the past.

Taboos and other cultural beliefs may serve to manage or protect wildlife by reducing the motivation to hunt particular species (Silberbauer, 1981; Smith, 1976b; Sponsel, 1980), and by distributing hunting pressure across a greater diversity of species (Århem, 1976). However, traditional belief systems are increasingly superseded by

western culture (Bennett, 1962; Dwyer, 1982; Hames, 1991). Market pressures undermine taboos to the extent that the market places a premium on previously unexploited species, encouraging individuals to violate cultural norms for material gain (Berlin and Berlin, 1983; Moran, 1981a). As other game declines, pressure increases to hunt tabooed species (Nietschmann, 1973; Peres, 1990). In some cases, although people will not consume certain species of game, they will kill that species when encountered because the meat can always be sold (Johnson, 1989; Sponsel, 1980). In other cases, previously "inedible" or tabooed species are being reclassified as edible (Hames and Vickers, 1982; Speth and Scott, 1989; Yost and Kelley, 1983).

When there are few visible signs of degradation, there are also few incentives to conserve wildlife resources, and formal institutions or controls on hunting activities do not develop (Harms, 1987; Mulongo, 1989; Testart, 1977). Mobile populations not tied to a specific resource base and defined territory gain little from prudent resource use (Gadgil et al., 1993). Alternatively, people may not perceive declining wildlife as a risk at all, or as a risk that they are able to address (Kottak and Costa, 1993). Often they are unable to restrict access to hunting areas and wildlife (Bahuchet, 1979b; Hames, 1986; Orejuela, 1992; Rodgers et al., 1991). Rather than a "tragedy of the commons" there is a tragedy of open access resources (Feeny et al., 1990;

Hardin, 1968; McCay and Acheson, 1987). Professional hunters from elsewhere have little difficulty in entering the area to pursue their short-term economic goals, while other immigrants can also freely establish residences and farms. Local people then lack the incentives to conserve wildlife resources because they bear all the costs and are able to capture few of the benefits in return.

The Subsistence Role of Hunting

The subsistence role of hunting for human populations depends on the other subsistence activities possible in the physical and cultural environment. Across the tropics, wildlife meat or "bushmeat" is an important subsistence resource for forest peoples. In west and central Africa, 60-80 percent of meat consumed by forest residents is bushmeat (Ajayi, 1979; Asibey, 1974; 1987; Heymans and Meurice, 1973; Martin, 1983; Prescott-Allen and Prescott-Allen, 1982).

The role of wildlife meat in the diet varies considerably over time, and among neighboring ethnic groups and settlements. People who do not farm depend more on wildlife for subsistence, both directly consuming the game they capture, and indirectly to the extent that they sell meat in exchange for other foods. Central African Pygmies traditionally maintained trading relationships with farmers of other ethnic groups (Bahuchet and Guillaume, 1979; 1982;

Bahuchet and Thomas, 1986; Berry et al., 1986; Delobbeau, 1989; Terashima, 1986). Similar long-standing symbiotic trading relationships occur in Brazil (Milton, 1984), and across Asia (Gardner, 1969; Griffin, 1981; 1984; Hoffman, 1988; J. Peterson, 1978a; 1981; Rai, 1982; Rambo, 1979a; 1980; 1982b). Although meat is traded, production is for subsistence at the local level: hunters provide the subsistence requirements of meat for both groups, while farmers provide the subsistence requirements of starch.

Cultivation methods and crops can affect hunting intensity and frequency. Certain crops like manioc require relatively little attention. Manioc farmers can therefore spend extended periods away from their fields hunting in the forest (Nietschmann, 1973). By dispersing fields throughout the forest, forest peoples can effectively expand their hunting range (Hart, 1979; Posey, 1985). On the other hand, crops that require much more care, for example rice or maize, reduce the time available for hunting, and often increase the reliance on trapping (Behrens, 1984; Carpaneto and Germi, 1992; Dwyer, 1985; Dwyer and Minnegal, 1991; Sandbukt, 1988; Sato, 1983). Thus, increasing dependence on agriculture may reduce the subsistence role of wildlife (Bahuchet, 1985b; Johnson, 1977). But by providing greater food security, which allows population density and settlement size to increase, cultivation may increase hunting pressure, particularly on large game species which

provide the highest returns (Speth and Scott, 1989; Werner et al., 1979).

Some researchers argue that cultivation can increase the abundance of game species, and therefore the potential subsistence role of hunting. Traditional shifting cultivation creates a mosaic of forest patches at different stages of regrowth⁸ (Bailey et al., 1990; Barnes et al., 1991; Hart and Petrides, 1987; Ross, 1978; Sato, 1983; Wilkie, 1987b; Wilkie and Finn, 1990), increases the abundance of forest/forest edge ecotones (J. Peterson, 1977; 1981; 1982), and provides food sources for wildlife in both current and abandoned farms (Linares, 1976; Posey, 1982; 1985). The vegetation diversity benefits many opportunistic or colonizing wildlife species, or those which depend on two or more habitat types, including important game species like pigs and deer in Asia, and rodents in Africa and Latin America (Dufour, 1990; Speth and Scott, 1989).

The Economic Role of Hunting

The boundary between subsistence and commercial production is often indistinct: all meat that is not consumed can be sold in local markets (Peres, 1990). For many forest peoples, hunting has for generations or even centuries had economic as well as subsistence objectives (Bower, 1989; Healey, 1990; Rambo, 1979b; Sellato, 1994;

⁸Selective logging can perform a similar function.

Spielmann and Eder, 1994). For the past 50 years, commercial hunting of crocodiles for skins has helped the Sirionó of Bolivia through annual periods of agricultural scarcity, and allows them to obtain luxury goods (Stearman and Redford, 1992). In fact, hunting is an integral part of all forest-based activities, a "subsidy from nature" without which other commercial activities like rubber tapping or Brazil nut collecting would not be possible (Hecht et al., 1988; Redford, 1992; 1993). Likewise, hunters supply meat to gold miners and loggers (Alvard, 1995; Stoll, 1992).

As urban populations increase, rural populations become ever more important as food producers. Urban areas, especially in Africa, exert a particularly strong pressure on hunters in forest areas to produce bushmeat (Anadu et al., 1988; Colyn et al., 1987; Falconer, 1990; Steel, 1994). This market provides a major income-earning opportunity for forest peoples who have in many cases benefitted little from development elsewhere in the country (Infield, 1988). Furthermore, professional hunters are increasingly turning their attention to forest areas as wildlife resources are depleted in more accessible regions (Rodgers et al., 1991). Urban dwellers in Ghana make weekend hunting trips to forest areas to earn supplementary income (Asibey, 1980).

The bushmeat trade increases the intensity of hunting by expanding the population base consuming the meat, and the time spent hunting (Colyn et al., 1987; Hart, 1978).

Commercial meat traders, by provisioning hunters with food and hunting equipment, can also promote the expansion of hunting into more remote areas that were previously inaccessible. Thus the distribution of Mbuti hunters in Zaïre no longer depends on the distribution of farming villages to supply their carbohydrate needs (Hart, 1979; Peacock, 1984). Trade also alters hunting methods by diffusing new technologies⁹ from outside forest areas, and by causing hunters to focus on more marketable prey species (Hayden, 1981).

The long-term indirect effects of trade on hunting and social change are difficult to predict (Godoy and Bawa, 1993). Trade may induce specialization by particular groups in hunting: trade allows neighboring ethnic groups to coexist by emphasizing narrower ecological niches, thus increasing the potential human carrying capacity of the environment and reducing the potential for conflict (Bahuchet et al., 1990; Berry et al., 1986; Fox, 1969; Headland, 1986; Milton, 1984; Peterson, 1978b; Turnbull, 1965). In Asia, the trade in wildlife products has affected hunting practices for centuries: inducing relatively sedentary agriculturalists to become mobile hunter-gatherers in order to more effectively harvest forest products for the market (Hoffman, 1986). Trade has encouraged the Miskito of

⁹For example, nets and crossbows in central Africa, and shotguns everywhere.

Panama to emphasize meat production at the expense of subsistence agriculture, to the extent that hunting activities conflict with cultivation for time, space and labor (Nietschmann, 1972; 1973). Alternatively, certain individuals within groups become professional hunters (Ayres et al., 1991; Carpaneto and Germi, 1992). The persistence of these specialist individuals or groups through time clearly depends on the persistence of wildlife as an economically important resource. Intensive exploitation may deplete wildlife to the point where it can no longer support specialized hunters. As they turn to alternative economic and subsistence activities, hunting will decline.

Conclusion

Based most importantly on the work of Julian Steward, cultural ecology combines theories and methodologies from geography, anthropology, and ecology. Cultural ecology attempts to grapple with the extremely complicated problem of human-environment interactions through a systems approach that integrates ecological and socioeconomic systems. It has provided a general framework for analysis of interactions, rather than specific methodologies of its own. Research has emphasized people-environment relationships in developing countries. In this way, cultural ecology can play an important role in guiding current efforts to integrate conservation and development, two subjects which

are particularly problematic in tropical forests. In recent years, natural scientists promoting ecosystem conservation and social scientists advocating human system "development" have begun to recognize the interdependencies of their two objectives.

This dissertation seeks to build upon and advance the theory and practice of cultural ecology described above. The field work continues in the geography and cultural ecology traditions to integrate disciplines and research subjects. Rather than analyzing the entire people/environment system, the dissertation focuses on hunting in order to investigate ecosystem/biodiversity conservation and human system/socioeconomic development, and attempts to integrate the two in a particular African case study.

Wildlife exploitation for subsistence and commercial purposes can contribute to socioeconomic development. If exploitation is sustainable, it can also support biodiversity conservation. But sustainable exploitation depends on appropriate management practices and the ecology of the resource base.

People are currently harvesting wildlife, and will continue to do so, throughout tropical forests because wild animals provide both protein and income. The complete prohibition of hunting is unrealistic and unenforceable. Integrated conservation and development projects seek to

direct this exploitation toward more sustainable practices and levels. Such a course of action requires accurate information on the ecosystem, in the form of biological and ecological data on local game species, combined with information on the human system, in particular on hunting methods, motivations, and harvest rates.

This dissertation provides both types of information for the Bayanga region of the Central African Republic based on 16 months of fieldwork, and complemented by data from research elsewhere. The following chapter describes the ecosystem and the human system of the Bayanga region. Chapters 4 and 5 report the results of the study of cable snare hunting and communal net hunting respectively.

CHAPTER 3 THE BAYANGA REGION

The cultural ecology framework emphasizes the relations between two systems: the ecosystem and the human system. The research site is the Bayanga region of the Central African Republic, the area south of Nola that is bounded by the Congo border to the east, the Cameroon border to the west (Figure 3.1). This chapter examines the components of each system in the Bayanga region.

The regional ecosystem, like other tropical rainforests, contains high species diversity of plants and animals. This chapter focuses on the resource base represented by the primary game species and implications for their sustainable harvesting. Components of the human system include political authorities, economic activities, and population centers. Change in each of these components over time in turn affects patterns of wildlife exploitation. In order to illustrate the influence of hunting on relations between the ecosystem and the human system in the Bayanga region, the chapter concludes by discussing several cases and issues: elephants, hunting legislation, bushmeat markets, and currency devaluation.

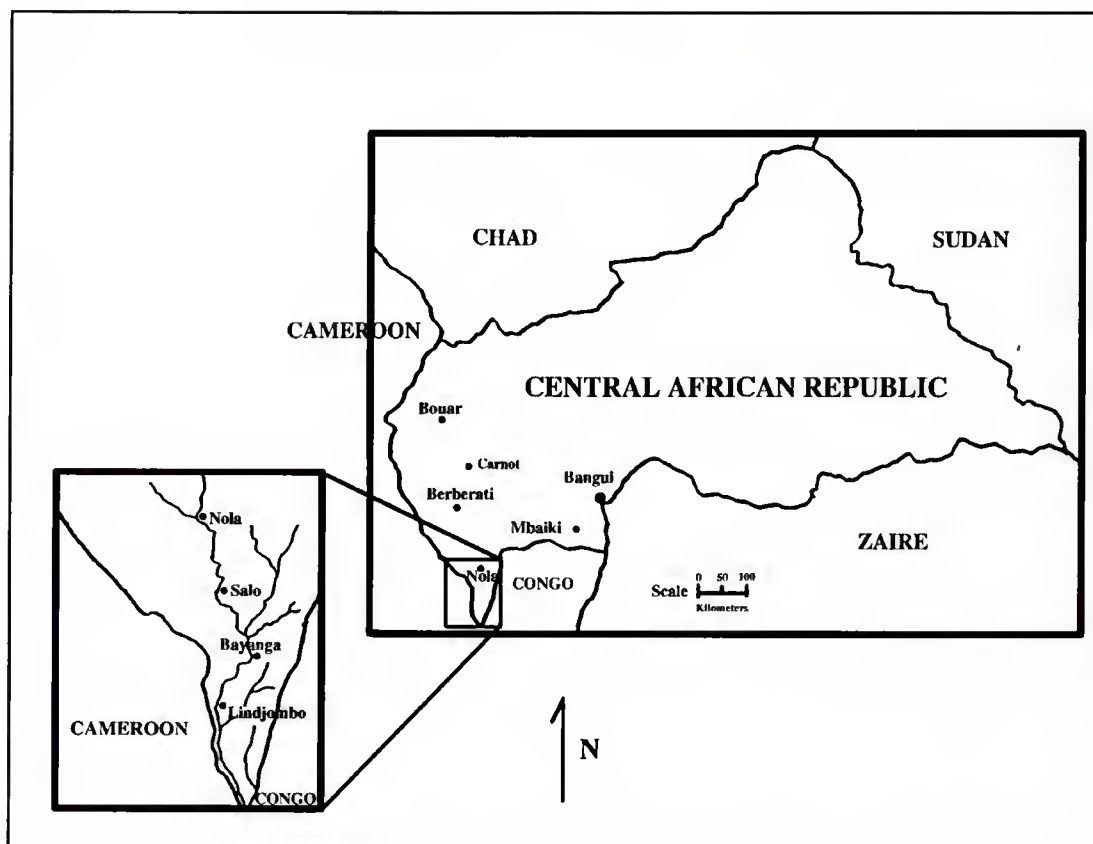


Figure 3.1: The Central African Republic and the Research Area

Source: Carroll, 1986b.

The Ecosystem

The tropical rainforest ecosystem of the Bayanga region is complex, and offers many resources that have long been exploited by colonial and independent governments, foreign companies, immigrants, and local residents. This section describes general ecosystem characteristics, then focuses on wildlife resources, which are exploited by local residents for food and for markets. The principal game species are described in detail, with particular attention given to

population densities, predictions of sustainable harvest rates, and the impacts of harvesting.

Ecosystem Characteristics

The Bayanga region lies at the upper limit of the great Congo basin tropical rainforest. Relief is relatively flat, averaging 350 meters in altitude to the east of the Sangha river, with hills rising to 700 meters to the west of the Sangha. The entire region is drained by the Sangha river, flowing south to the Oubangui and the Zaire rivers. Seasonal temperature variations are slight: monthly averages vary only 2° Celsius. But diurnal variations are as high as 14° C (Figure 3.2). Average annual rainfall of less than 1,400 millimeters is low for a rainforest (Richards, 1952). A three-month dry season lasts from December to February, though it does rain during this period (Figure 3.3). Because of these relatively constant and stable climatic conditions, most animals are permanent residents that do not make long-distance seasonal migrations, and reproduction continues throughout the year.

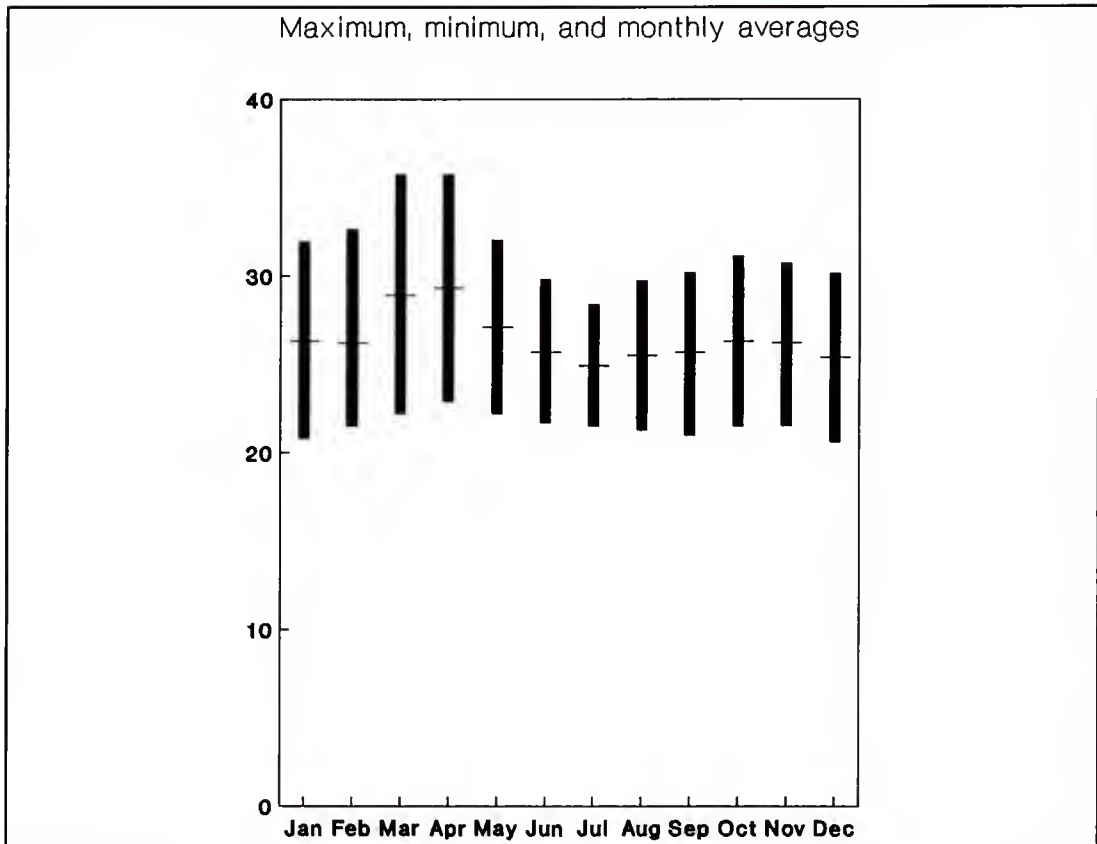


Figure 3.2: Average Temperatures (°C): Bayanga, 1974-1984

Source: Carroll, 1986b.

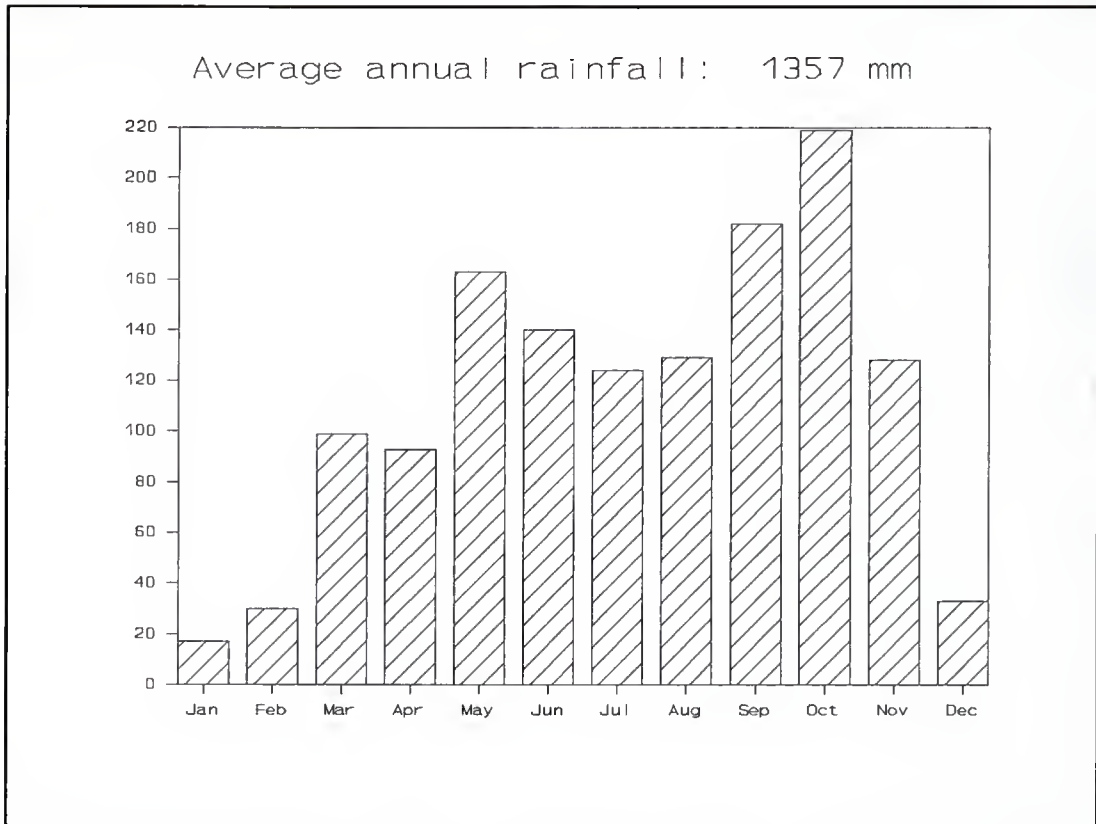


Figure 3.3: Average Rainfall (mm): Bayanga, 1973-1984

Source: Carroll, 1986b.

Forest types include evergreen, deciduous and evergreen-deciduous transition forests. Closed forest formations cover 94 percent of the 8,330 km² area from Nola south, including mixed forests and patches of *Gilbertiodendron dewevrei* monodominant stands on well-drained soils (Figure 3.4). Poorly-drained soils are covered with almost pure stands of *Guibourtia demeusii*, *Gilbertiodendron dewevrei*, or raffia palms (*Raphia* sp.).

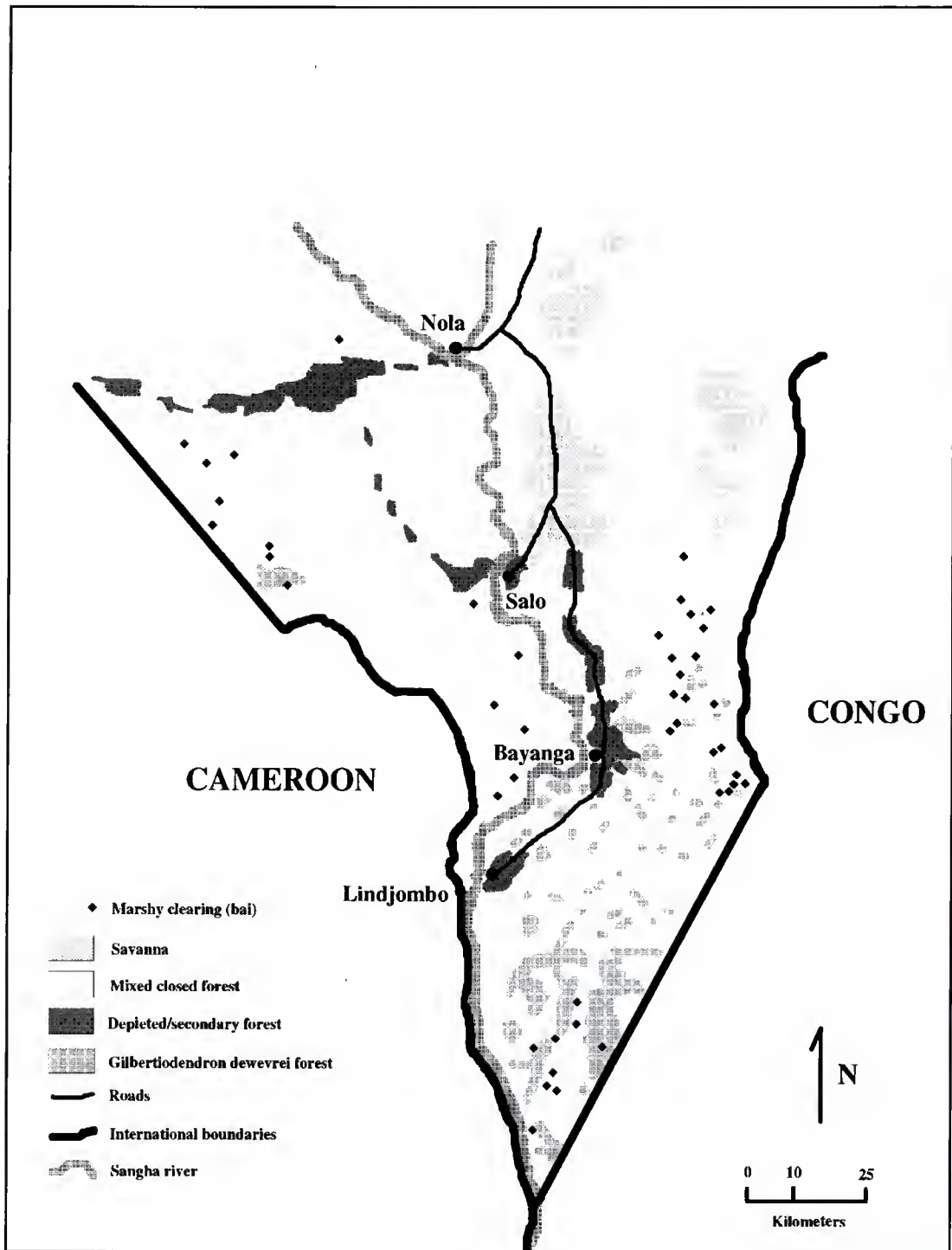


Figure 3.4: Vegetation of the Bayanga Region

Source: Carroll, 1986b.

Patches of savanna occur to the northeast. Herbaceous marshy forest clearings called "baï" are maintained, and perhaps created, by heavy wildlife usage, particularly elephants searching for minerals in the soil (Carroll, 1988).

Wildlife diversity, as in other tropical forests, is high (see Appendix 1 for a species list). Wildlife exploitation focuses primarily on mammals, although many species of birds, reptiles, and insects are also collected. The most important mammal species from a conservation perspective are the forest elephant (*Loxodonta africana cyclotis*) and the lowland gorilla (*Gorilla gorilla gorilla*) which have been surveyed locally by Carroll (1986c; 1988) and Fay (1989; 1991).¹

In addition, a variety of ungulate species are present: forest buffalo (*Syncerus caffer nanus*), bongo and sitatunga antelope (*Tragelaphus euryceros* and *T. spekei*), seven species of duikers (*Cephalophus* spp.) and two types of pigs (*Potamochoerus porcus* and *Hylochoerus meinertzhageni*) (Fay et al., 1990; Wilson and Wilson, 1989). Fifteen species of primates occur, including chimpanzee (*Pan troglodytes*) and several species of monkeys (*Cercopithecus* spp., *Cercocebus* spp., *Colobus guereza*, and *Procolobus badius*). The carnivores include leopard (*Panthera pardus*), golden cat

¹Additional research is in progress: on elephants by Andrea Turkalo, and on gorillas by Melissa Remis and Michele Goldsmith.

(*Profelis aurata*), and several mongoose and genet species (*Viverridae*) (Blom, 1993; Carroll, 1986b; 1986c).²

Most forest mammals that are primary consumers are frugivorous, though the larger species also browse. Grazing is limited to the several dozen marshy clearings and is probably only important to buffalo. However, many other species also frequent baïs to obtain minerals such as calcium. The Dzanga bai, 300 meters by 150 meters, is most noteworthy for the spectacle of elephant agglomerations exceeding 100 individuals.³ In addition to the elephants, present virtually 24 hours a day since anti-poaching efforts took effect in 1988, other species seen at Dzanga include buffalo, bongo, sitatunga, black-fronted duiker, bush pig, giant forest hog, as well as flocks of African grey parrots. Gorillas visit some of the other baïs.

Wildlife abundance and dispersal is related to the nature of food resources. The diversity of trees and the relatively weak seasonality ensures that some species are fruiting at all times of the year, but the food resources are patchily distributed. In order to exploit these resources, animals which forage in groups move around extensive areas. These animals include the diurnal primates

²Justina Ray has studied mongooses in the Bayanga region.

³Unlike savanna elephants, the forest subspecies forms only small groups of 2-4 individuals (Merz, 1986; White et al., 1993).

and the larger terrestrial mammals such as elephants, buffalo, bongo, and bush pigs. The smaller terrestrial mammals such as sitatunga and all duikers) are relatively sedentary and solitary.

The four principal game species exploited by local people, for subsistence and for the trade in bushmeat, are the brush-tailed porcupine (*Atherurus africanus*) and three duikers (*Cephalophus callipygus*, *C. dorsalis*, and *C. monticola*). These species are described in detail below.

Species Characteristics

Appendix 2 provides biological information for the four game species, based on measurements of captured animals in the Bayanga region and on detailed studies by researchers elsewhere in Africa. Information on duiker reproduction is inconsistent, but the most accurate information is available from Vivian Wilson's on-going breeding research at Chipangali Wildlife Trust in Zimbabwe. Duikers bear only one young at a time. They breed continuously throughout the year, although birth rates are somewhat higher in particular seasons of the year. Individuals of all species reach sexual maturity (first oestrus) at 11 months, and after a gestation period of 7 months produce their first offspring at 18 months. Conception occurs again within days of parturition. Therefore female duikers reproduce every 210 days, and are pregnant virtually continuously. Reproductive

rates in the wild may be somewhat lower, perhaps one young per female per year. Longevity is probably 8-10 years. Very little is known about *A. africanus*, but it is thought to reach sexual maturity at two years of age, and to reproduce one young at a time after a gestation period of 100-110 days (Rahm, 1962).

Individuals of all duiker species are generally solitary, except for *C. monticola* which often forage in pairs or even small groups including two parents and a young animal (Dubost, 1980). *A. africanus* forages alone, but is less territorial than the duikers, with several individuals and families sharing a sleeping area (Emmons, 1983).

All species are principally frugivorous, though the duikers browse as well, and *A. africanus* digs for roots and tubers. In addition, duikers consume small amounts of animal matter and insects in order to obtain necessary salts (Kingdon, 1982). Duikers consume fruit in direct proportion to fruit abundance: when fruit is not available, more leaves are consumed (Feer, 1989a). In the rain forests of Gabon and Zaïre fruits comprise more than 70 percent of the diet throughout the year (Table 3.1).⁴

⁴But in South African dry forests, where fruit is not a reliable resource, *C. monticola* depends on leaves for 70 percent of its diet (Faurie and Perrin, 1993).

Table 3.1: Game Species Activity, Weight, and Diet
(diurnal/nocturnal, kgs, percent of fruit/leaves in diet)

	<u>Activ</u>	<u>Weight</u>	<u>Fruit</u>	<u>Leaves</u>	<u>Fruit^c</u>	<u>Fruit^d</u>
<i>C. callipygus</i> ^a	D	20.1	82.7	16.3	86-89	88
<i>C. dorsalis</i> ^a	N	21.7	72.9	26.6	86-89	75
<i>C. monticola</i> ^a	D	4.9	78.5	20.3		75
<i>A. africanus</i> ^b	N	3.3				

Activity: D=diurnal, N=nocturnal.

Weight: average for species, in kg.

Fruit: percent of fruit in diet (dry weight).

Leaves: percent of leaves in diet (dry weight).

Sources: From Gabon: ^aDubost, 1984; ^bEmmons, 1983; and
^cFeer, 1989a. From Zaïre: ^dHart, 1985.

Because ecological conditions in the Bayanga region are relatively stable and predictable, ranges and diets likewise do not vary much. Most duikers exhibit little weight change in the dry season, when food resources are least abundant, although the larger duikers expand their home ranges during this season (Dubost, 1984). All four species are territorial, and they probably remain on the same territory throughout their lifetime. In South Africa, *C. monticola* are so strongly territorial that they rarely leave their home range even when beaters shouting and shaking leaves try to drive them out: instead they double back through the line of beaters or hide (Bowland, 1990). More detailed information on the four game species is provided below.

Atherurus africanus

A. africanus is strictly nocturnal, hiding by day in thick brush or in burrows abandoned by other animals. It may use the same shelters for many years, with well-defined

paths to established feeding areas. It forages alone, but often joins others in dens during the day. Studies in Gabon find home ranges averaging 13.3 hectares. However, it is possible that members of a clan share a territory (Emmons, 1983; Kingdon, 1982; Rahm, 1962).

Cephalophus callipygus

C. callipygus males maintain a home range of 27-49 hectares, while females' home ranges are 40-42 hectares. Territories are larger in the dry season. Reproduction is continuous throughout the year. *C. callipygus* prefers primary forest with relatively thin undergrowth (Estes, 1991; Feer, 1989a; 1989b).

Cephalophus dorsalis

C. dorsalis is strictly nocturnal, and is much less active than the diurnal *C. callipygus*, covering in its daily foraging only one-fourth the distance that the latter covers (Estes, 1991). It hides in tree hollows or very thick brush by day, but at night forages in more open areas. Studies in Gabon find male home ranges (79 hectares) overlapping two female home ranges (41 hectares), and territories are larger in the dry season (Dubost, 1983; Feer, 1989a; 1989b). Research in Zaïre reports territories averaging 15.2 hectares, but individuals also will make direct long-distance moves to known food patches (Hart, 1985).⁵

⁵Reported differences in home range size may result from different research methods, or from habitat differences.

Cephalophus monticola

C. monticola occupies all types of forest where the undergrowth is sufficiently clear (visibility greater than 20 meters), including primary and secondary forest resulting from cultivation and logging (Fimbel, 1994). It forages in these clear areas, but rests and hides from danger in denser vegetation and brush (Estes, 1991; Hanekom and Wilson, 1991). It is exclusively diurnal, and is active for a longer period in the dry season, perhaps because less food is available.

Studies find male-female pairs sharing territories of 3.7-6.4 hectares in Zaïre (Hart, 1985), and 2.5-4 hectares in Gabon (Dubost, 1980). The home range varies little with the seasons, remaining quite stable throughout the adult's life. Each family member protects its territory from outsiders of the same sex. Males may venture out of their territories but only 100-300 meters to a particular fruiting tree, and for a few hours at most. Male-female pairs forage together or alone, but are sometimes accompanied by their own or migrant young. The young migrate to find unoccupied territories, and annual population turnover is from 7-10 percent (Dubost, 1980; 1983). Reproduction occurs throughout the year, but is relatively more common in the dry season (Mentis, 1972).

Population Characteristics

This section describes population characteristics of the four game species, most importantly population densities, age structure, and sex ratios. These characteristics are critical in determining the effects of hunting on game species, and especially in evaluating whether hunting is sustainable.

Population densities

Densities are the population characteristic most often measured in the field (Table 3.2). Density estimates may vary because of differences in methodologies: track and pellet counts, line transect surveys, and radio-telemetry. Variations among research sites also result because of differences in ecological interactions such as vegetation types or competition with other frugivores, as well as differences in patterns of human intervention: hunting pressure and habitat disturbance.

Table 3.2: Population Densities for Game Species
at Research Sites in Gabon, Zaïre and Cameroon
(individuals per square kilometer)

	<u>(1)</u>	<u>(2)</u>	<u>(3)</u>	<u>(4)</u>	<u>(5)</u>	<u>(6)</u>
<i>A. africanus</i>	77.7	12.0 ^a	45.1 ^b			30.0
<i>C. monticola</i>	70	30.4-53.0	62-78 ^c	14.9	61-69	
<i>C. callipygus</i>	10.7-15.5	0.6-6.7		3.2		
<i>C. dorsalis</i>	6.3-8.7	2.5-6.8		1.5		

Sources: For Gabon: (1) Feer, 1988; 1989b; 1993; (2) Lahm, 1993; (3) ^bEmmons, 1983; and ^cDubost, 1980. For Zaïre: (4) Hart, 1985; (5) Wilkie, 1987b. For Cameroon: (6) Payne, 1992.

Methods: I have included duiker densities only for sites in Gabon and Zaïre, because the same guild of duiker species occurs in these sites as in the Bayanga region.

Feer, Dubost, Emmons and Hart used radio-telemetry to measure home ranges. This is the most accurate method of determining population densities. ^bEmmons provides only average home ranges for *A. africanus*, which I have used to calculate densities assuming seven individuals per adult home range.

Hart also conducted censuses using groups of net hunters, as well as pellet and track count surveys. Wilkie conducted track and pellet count surveys as well.

Lahm and Payne conducted day and night line transects. ^aLahm recorded only encounter rates for *A. africanus*, which I have used to calculate approximate densities according to Payne's (1992) mean sighting distance for the species in night transect surveys.

Age structure and sex ratios

Emmons (1983) reports that males comprise 52 percent of subadult *A. africanus*, and 58 percent of adults. The only age structure and sex ratio information on duikers in the literature is for *C. monticola* in Gabon (Table 3.3).

Table 3.3: Age Structure for *C. Monticola*
(number and percent female/male by age classes)

In region (results from hunting)

	<u>Embryos</u>	<u>Births</u>	<u>M0</u>	<u>M1</u>	<u>M2</u>	<u>Subad</u>	<u>Adults</u>	<u>Repr</u>
Number	20	10	11	8	29	22	54	76
Female (%)	30	50	62	75	59	69	44	51
Male (%)	70	50	38	25	41	31	56	49

In study area

	<u>Embryos</u>	<u>Births</u>	<u>M0</u>	<u>M1</u>	<u>M2</u>	<u>Subad</u>	<u>Adults</u>	<u>Repr</u>
Number	--	--	5	13	28	23	79	102
Female (%)	--	--	60	68	54	67	49	53
Male (%)	--	--	40	32	46	33	51	47

Notes: M0 = 0-4 months old, no molars visible.

M1 = 4-10 months old, 1st molar erupting, but not 2nd.

M2 = 10-20 months old, 1st and 2nd molars out, but not 3rd.

Subad = sub-adults, 20-28 months, complete dentition.

Adult = older than 28 months, tooth wear visible.⁶

Repr = Total reproducing individuals including adults and subadults.

Source: Dubost (1980), p. 247. Reprinted with permission of the publisher, Blackwell Wissenschafts-Verlag GmbH, Berlin.

Dubost assumes that all individuals in the subadult and adult age classes are breeding. However, young individuals without territories probably cannot breed successfully, so the actual breeding population may be smaller than the number of sexually mature individuals. The age and sex structure data for *C. monticola* exhibit a strong deficit of young males in the population--these are the individuals most constrained by intraspecific competition for unoccupied territories (Dubost, 1980). Young are forced by their

⁶These age categories do not correspond to those of Vivian Wilson, who finds captive duikers reaching sexual maturity, and presumably having complete dentition, within one year. However, most mammals grow more quickly and reproduce at an earlier age in captivity than in the wild.

parents to emigrate and find unoccupied areas to claim for themselves. Their survival therefore depends on being able to find a suitable territory. Territoriality is determined by the availability of food resources as well as competition for enemy-free space. Mortality results from young being forced into more unsafe environments, for example outside protected areas or near human settlements.

Ecological interactions

The net effects of other species on the game species are complex interactions of predation, competition, and facilitation. Natural predators of duikers and porcupines in the Bayanga region include leopards, golden cats, eagles, pythons and large vipers. Other natural forms of mortality include old age, disease, starvation, and accidents.⁷ Natural mortality removes territorial adults and creates gaps for young individuals without territories to colonize. Mortality rates from natural causes for young duikers less than two years of age are high: 30 percent for *C. monticola*, 70 percent for *C. callipygus*, and 87 percent for *C. dorsalis* (Dubost, 1980; Feer, 1988).

The game species also compete with other frugivores, for example, monkeys, squirrels, birds, and elephants (Gautier-Hion et al., 1980). One study suggests that duiker

⁷During my fieldwork net hunters found a dead sitatunga mired in mud, and a hippopotamus died near Bayanga in the same way. Several years previously a dead elephant was found trapped between a tree and a river bank.

densities are lower where abundant elephants compete with duikers for fruit (White, 1994a). But game species derive benefits from other animals at the same time: arboreal frugivores pick fruits and drop them to the ground, so duikers often follow and feed below mixed monkey troops (Fay, 1989; Feer, 1989a). An estimated 50 percent or more of fruit available to terrestrial ungulates consists of fruit or parts of fruit discarded by primates (Hart, 1985). Furthermore, elephants benefit duikers by clearing trails through the forest, and by maintaining baï clearings where minerals are available (Carroll, 1986a; 1986c).

Estimated Population Densities in the Bayanga Region

Researchers have employed a variety of techniques to estimate population densities of terrestrial wildlife in African forests: day and night line transects, pellet and track counts, and radio-telemetry (Dubost, 1980; Emmons, 1983; Feer, 1989b; Fimbel, 1994; Hanekom and Wilson, 1991; Hart, 1985; Heymans and LeJoly, 1981; Lahm, 1993; McCoy, 1995; Nummelin, 1990; Payne, 1992; Struhsaker, n.d.; White, 1994a; Wilkie, 1987b). Radio-telemetry is the most accurate method, yet also the most expensive and time-consuming. All other methods are problematic, especially for counting small cryptic animals such as duikers in thick vegetation. Census methods are therefore more reliable for determining indices of abundance rather than absolute density estimates.

Line transect surveys

I chose to conduct day-time line transect surveys for several reasons. Because a conveniently-located set of transects already existed, this method was the easiest and conflicted least with other research activities. In addition, pellet and track counts are unable to distinguish between *C. callipygus* and *C. dorsalis*. Finally, night transects can be dangerous where elephants, gorillas, and gun hunters are numerous.

Between December 1993 and October 1994 I conducted a total of 97.7 kilometers of surveys along a set of transects established by the World Bank-funded Projet d'Aménagement de Ressources Naturelles between Mossapoula and Bayanga (World Bank, 1990). The transects are four parallel and straight paths roughly two meters wide, each two kilometers in length, and 500 meters apart. The perpendicular paths connecting the ends of the four parallel trails--two 500 meter sections at the east end, and a single 1,500 meter section at the west end--were also censused. Figure 3.5 shows the location of line transect surveys, as well as the net hunt censuses described below. Two observers walked together at a pace of 1-1.5 kilometers per hour, beginning between 10 a.m. and noon, and covering 5-6 kilometers per day. For each animal seen or heard, I recorded the following information: species, number, angle, perpendicular distance from

transect, animal to observer distance, forest type, and time. Duikers often whistled in alarm as they flushed.

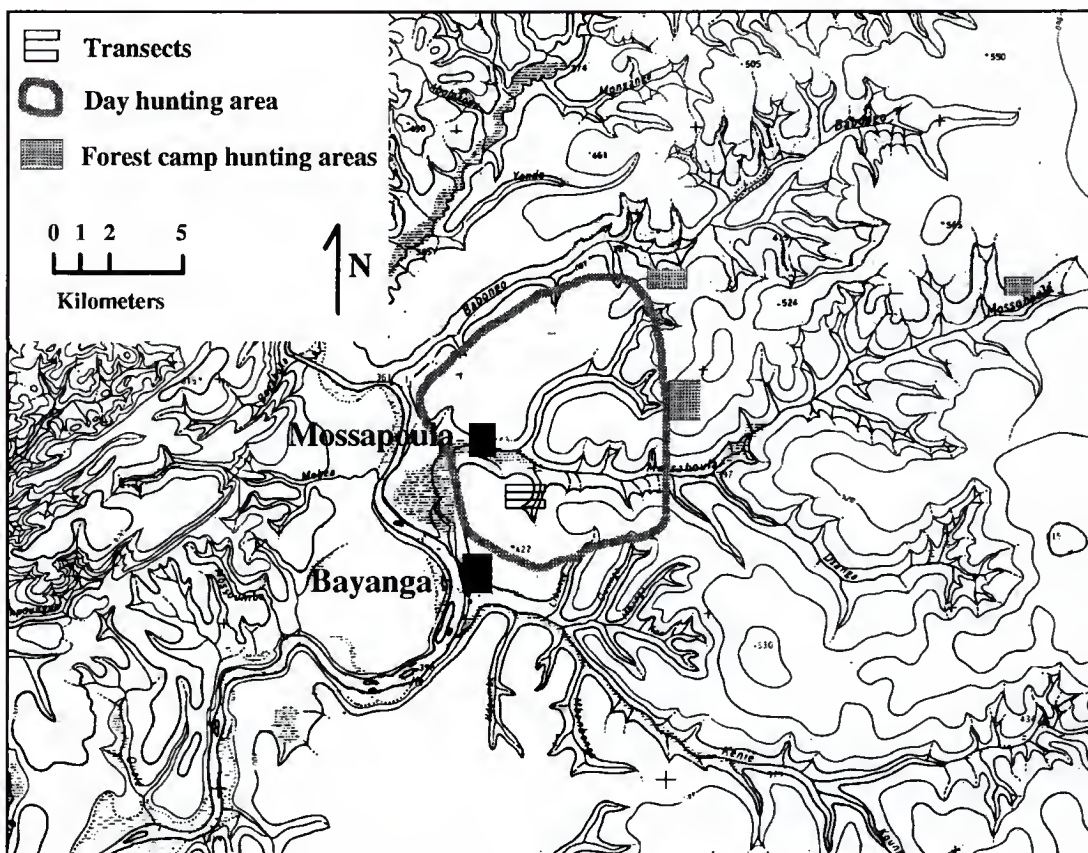


Figure 3.5: Location of Line Transect and Net Hunt Surveys

The method makes the following assumptions: 1) all animals on the transect line are seen; 2) each animal's position is fixed before it moves away from the observer; 3) no animal is counted twice; 4) distance measurements are exact; and 5) sightings are independent events (Anderson et al., 1979; Burnham et al., 1980; Eberhardt, 1978). All assumptions were probably violated in practice. Duiker flight responses depend on the vegetation. Where the

understory is relatively clear, duikers tend to move away quietly and are not observed at all, or they flush further away from the observer than their original position. Where the understory is thicker, duikers more often freeze and flush when the observer is very close, or remain hidden. Duikers, and especially the nocturnal bay duiker *C. dorsalis*, may hide in thick brush in the middle of the day when most censuses were conducted. Angle and distance data are estimates and were not measured exactly. Finally the sample size for all species is too small for reliable density estimates.⁸ Nevertheless, I present the information because no other data are available on duiker population densities for the Bayanga region (Table 3.4). No *A. africanus* were encountered.

Population density is calculated using the following formula (Whitesides et al., 1988):

$$D = (N * 1000) / 2LW$$

The width of the census path *W* is two times the mean sighting distance for each species, assuming that the same number of animals beyond this distance were seen and included as were missed within the sighting distance. Two alternative sighting distances are used in the table above: *W*₁ is the perpendicular animal-to-path distance, and *W*₂ is the animal-to-observer distance. The differences in density

⁸Buckland et al. (1993) recommend a minimum sample size of 60-80 individuals.

estimates according to the two sighting distances are statistically significant for *C. monticola* (Wilcoxon matched-pairs signed-ranks test, $T_s = 0$, $p < 0.01$).

Table 3.4: Estimated Population Densities
from Line Transects (animals/km²)

	<u>N</u>	<u>L</u>	<u>E</u>	<u>W1</u>	<u>SD (+)</u>	<u>D1</u>
<i>C. monticola</i>	33	97.7	0.34	9.03	7.57	18.70
<i>C. callipygus</i>	4	97.7	0.04	18.25	9.44	1.12
<i>C. dorsalis</i>	1	97.7	0.01	20.00	--	0.26

	<u>N</u>	<u>L</u>	<u>E</u>	<u>W2</u>	<u>SD (+)</u>	<u>D2</u>
<i>C. monticola</i>	33	97.7	0.34	16.11	9.36	10.48
<i>C. callipygus</i>	4	97.7	0.04	22.00	13.49	0.93
<i>C. dorsalis</i>	1	97.7	0.01	20.00	--	0.26

Notes: N = number of individuals seen

L = length of transect (km)

E = encounter rate (individuals/km)

W1 = mean animal to path distance (m)

W2 = mean animal to observer distance (m)

D1 = population density (individuals/km²) based on animal to path distance

D2 = population density (individuals/km²) based on animal to observer distance

SD = standard deviation of W1 and W2 respectively.

Although the transects covered both mixed (8,325 meters $\approx$ 80 percent) and monodominant *Gilbertiodendron dewevrei* forest (2,175 meters $\approx$ 20 percent), only two observations (5 percent), both of *C. monticola*, were in monodominant forest. The transect area was regularly visited by net hunters from Mossapoula, as well as by residents of both Bayanga and Mossapoula seeking other forest products. Therefore human disturbance was high, resulting perhaps in low actual densities. Transect surveys may also underestimate actual

densities at this site if animals are wary and avoid detection by census takers.

Net hunt encounters

In addition to the line transect censuses, I have also estimated population densities based on encounters during net hunts from Mossapoula and from forest camps (Table 3.5). Ichikawa (1978) also used encounters within the enclosed circle of nets to estimate population densities for *C. monticola* of 70-120/km². Other researchers have censused duiker populations using groups of observers with nets, setting the nets randomly and counting only the animals inside the enclosed area (Dubost, 1980; Hart, 1985; Koster and Hart, 1988). However, because I was observing hunters, the census path was not random: they do not hunt in *Gilbertiodendron dewevrei* forests or in marsh/swamp forests.⁹ And within the mixed forest where they hunt, they encircle and search areas with patches of thick brush or treefalls, where animals are more likely to hide.

⁹In general, *Gilbertiodendron dewevrei* forest has a very open understory, with few hiding places. Marsh and swamp forest is too thick and wet for net hunting.

Table 3.5: Estimated Population Densities
from Net Hunt Encounters (animals/km²)

Distance from
Mossapoula

<u><5 kms (N=39 hunts)</u>	<u>N1</u>	<u>D1</u>	<u>SD (+)</u>
<i>C. monticola</i>	297	80.8	235.82
<i>A. africanus</i>	80	21.8	24.64
<i>C. dorsalis</i>	43	11.7	60.12
<i>C. callipygus</i>	26	7.1	11.84
	<u>N2</u>	<u>D2</u>	<u>SD (+)</u>
<i>C. monticola</i>	324	10.7-32.6	10.10-35.75
<i>A. africanus</i>	82	2.7-8.3	2.54-7.92
<i>C. dorsalis</i>	53	1.8-5.3	2.66-9.39
<i>C. callipygus</i>	28	0.9-2.8	1.41-4.41
<u>5-10 kms (N=22 hunts)</u>	<u>N1</u>	<u>D1</u>	<u>SD (+)</u>
<i>C. monticola</i>	308	101.8	54.17
<i>A. africanus</i>	71	23.5	13.04
<i>C. dorsalis</i>	23	7.6	8.09
<i>C. callipygus</i>	24	7.9	7.08
	<u>N2</u>	<u>D2</u>	<u>SD (+)</u>
<i>C. monticola</i>	335	14.8-44.1	6.19-18.78
<i>A. africanus</i>	81	3.6-10.7	2.36-6.94
<i>C. dorsalis</i>	27	1.2-3.6	1.05-3.12
<i>C. callipygus</i>	28	1.2-3.7	1.10-3.28
<u>10-15 kms (N=6 hunts)</u>	<u>N1</u>	<u>D1</u>	<u>SD (+)</u>
<i>C. monticola</i>	48	188.3	99.68
<i>A. africanus</i>	15	58.9	68.52
<i>C. dorsalis</i>	5	19.6	54.81
<i>C. callipygus</i>	2	7.9	58.94
	<u>N2</u>	<u>D2</u>	<u>SD (+)</u>
<i>C. monticola</i>	61	20.4-66.9	5.80-20.48
<i>A. africanus</i>	16	5.3-17.6	3.93-13.66
<i>C. dorsalis</i>	6	2.0-6.6	2.59-9.23
<i>C. callipygus</i>	3	1.0-3.3	3.13-10.95

Notes: N = number of animals encountered (captures and escapes) by the entire net hunting group: N1 = encounters inside the net circles; N2 = total encounters during hunt.

D = population density (individuals/km²). D1 is based on the area inside the net circles. D2 is based on the total area searched by the net hunting group, assuming a path width between one and two times the net circle diameter, and a path length based on the net circle diameter and a 100-200 meter distance between casts.

The first density estimate (D1) is based on the area inside the circles enclosed by the nets. The area is determined by the number of nets used per hunt (maximum 20), an average net length of 18.27 meters (N=54), and the number of times the nets are set. I assume that all circles during a given hunt are the same area, but the area varies between hunts according to the number of nets. The number of animals "censused" includes all captures and escapes from inside the circles. I have excluded occasions when an animal was seen first, and the nets were then set to capture that animal.

The second density estimate (D2) is based on the total area searched by the net hunters. In practice, the width of the search path varies considerably: at times the hunting group is close together near the nets, at other times the group is spread over a considerable area as individuals lag behind or detour to gather other forest products. I calculate the daily path width using two alternative measurements: one and two times the diameter of the net circle. The distance between casts also varies. I have calculated the daily path length according to the circle diameter, the number of times the nets are set, and two alternative distances between sets: 100 and 200 meters. The number of animals censused includes all animals seen during the hunt. The result for each hunt is a range of densities according to alternative path width and length

calculations, of which I have presented the minimum and maximum values above. Multiple hunts are grouped together and average densities are derived from the combined total area and total encounters.

The method makes two important assumptions: 1) all animals in the searched area are seen, both inside and outside the net circles, including animals that escape; and 2) the nets are set in a closed circle. But the level of hunting effort determines whether all animals are seen, and effort varies during as well as between hunts. When beating is very quiet and uncoordinated, few animals are seen, and actual densities probably exceed those estimated. Areas between casts are not searched as carefully as the area inside net circles, because hunters expect to find game more frequently in areas that they encircle. The net circle also varies in size during a hunt as the number of nets changes from set to set.

The method is therefore not reliable for determining absolute population densities of game species, yet it can provide an index to compare population abundances among areas and over time. The method takes advantage of the available information, and is relatively simple to replicate with data on the following three variables: number of nets, number of times the nets are set, and number of animals encountered by species. Daily path width and length can also be determined accurately with more precise data.

The first density calculation (D1) perhaps is biased upwards, because hunters only encircle areas where they most expect to find game. The second density estimate is probably more representative of the area as a whole, because the hunters' path crosses monodominant and mixed forests, and the number of animals encountered includes those seen outside the enclosed circles. In general, net hunt encounters are likely to underestimate densities for *A. africanus* and *C. callipygus*. The former hides by day in hollow trees, holes in the ground, or thick brush: although some are flushed by net hunters, some undoubtedly remain hidden. *C. callipygus* is active by day, with a large home range compared to *C. monticola*, therefore it is more likely than the other duikers to move away from approaching net hunters. This is supported by the findings that snare encounters of *C. callipygus* were 4.2 times more abundant than *C. dorsalis* in the Bayanga region. My line transect surveys also found *C. callipygus* to be 3.6-4.3 times more abundant than *C. dorsalis*, though with very few encounters of either species.

Net hunt encounters may not provide accurate density estimates, but are at least useful as a comparative index of density. The effects of hunting on game populations depend on hunting intensity, which can be measured by the number of hunts per square kilometer per year. Net hunting intensity declines as distance from Mossapoula increases (see Chapter

5 for a discussion of net hunting intensity). However, wildlife population densities do not increase uniformly with distance from Mossapoula (Figure 3.6).

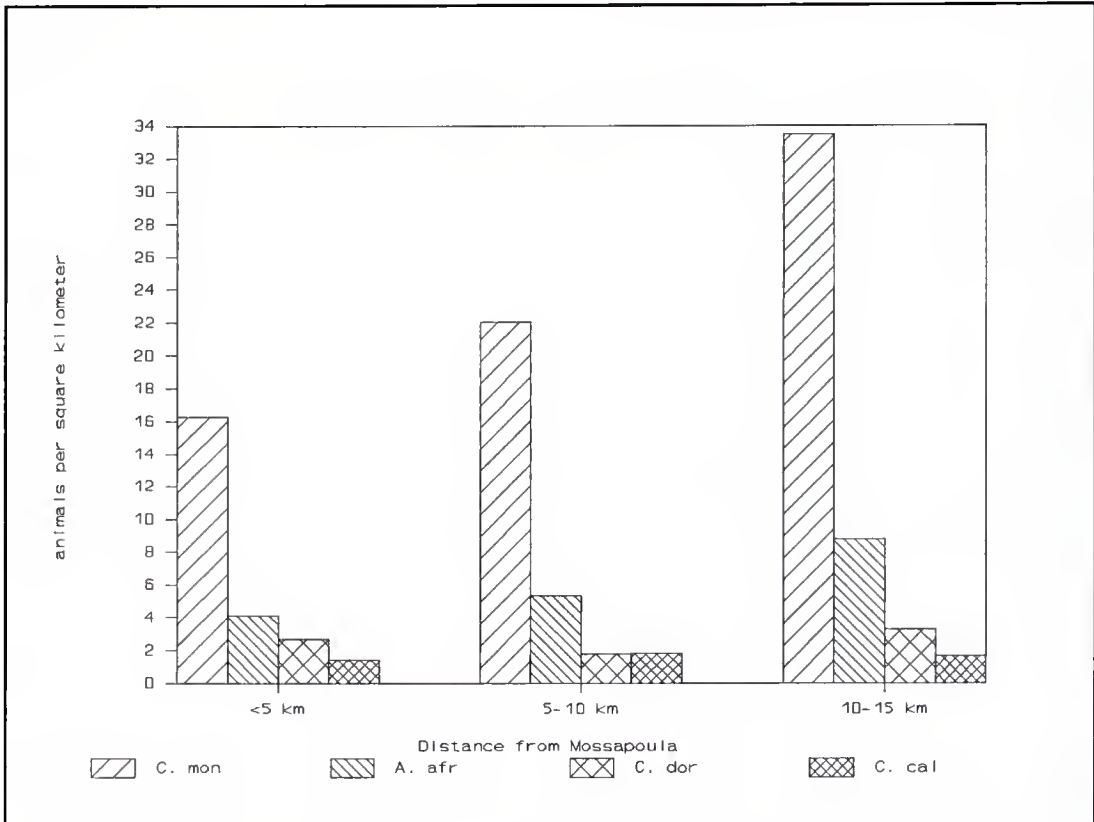


Figure 3.6: Population Densities of Game Species: *C. monticola*, *A. africanus*, *C. dorsalis* and *C. callipygus*.

Note: Data are the mean D2 values from Table 3.5.

A Spearman rank correlation coefficient test on the 61 net hunts in Table 3.5 finds population densities increasing with distance from Mossapoula for *C. monticola* ($r_s = 0.417$, $p < 0.01$), *A. africanus* ($r_s = 0.247$, $p < 0.025$) and *C. callipygus* ($r_s = 0.246$, $p < 0.025$). However, distance from Mossapoula explains little of the variation in densities--at

most 40 percent in the case of *C. monticola*. There is no statistically significant relationship between distance and density for *C. dorsalis* ($r_s = 0.106$). Figures 3.7-3.10 provide the density data for each species.

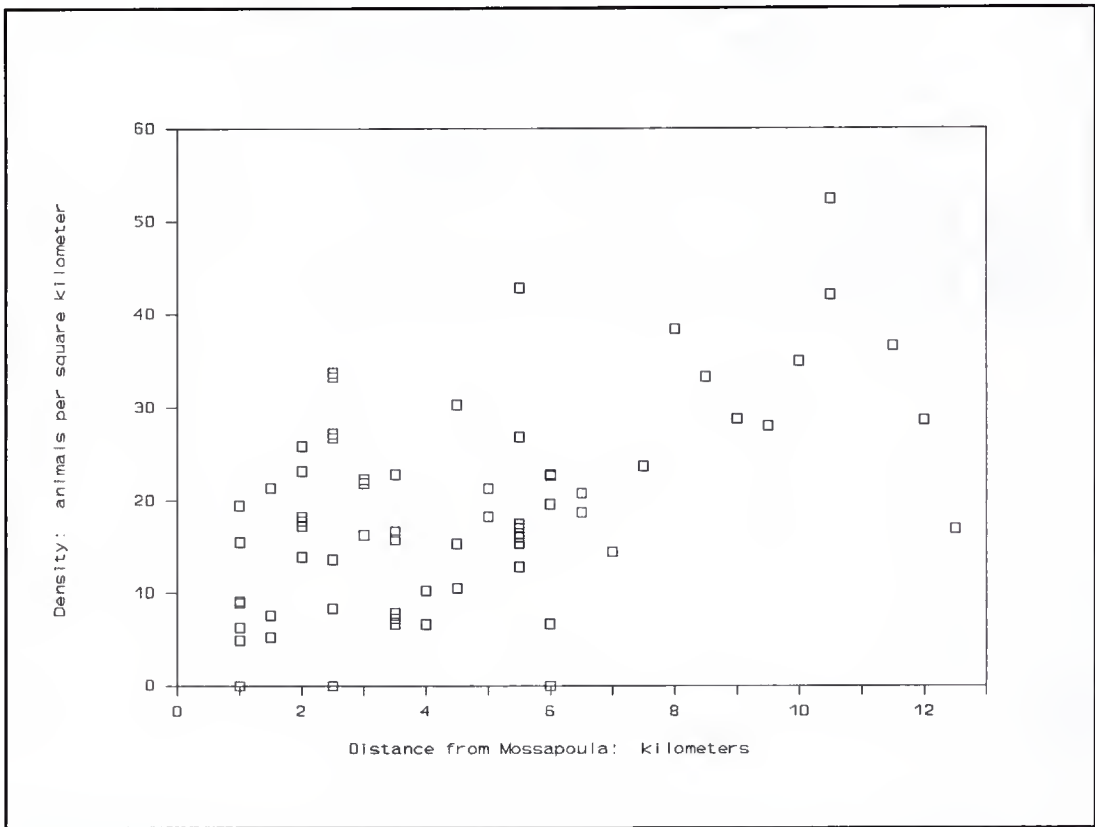


Figure 3.7: *C. monticola* Population Densities from Net Hunt Encounters (individuals per square kilometer, $N = 61$ net hunts).

Notes: $r_s = 0.417$, $p < 0.01$.

Data are the mean D2 values, with one outlying value excluded: $D = 114.83$ for a hunt 0.5 kilometers from Mossapoula.

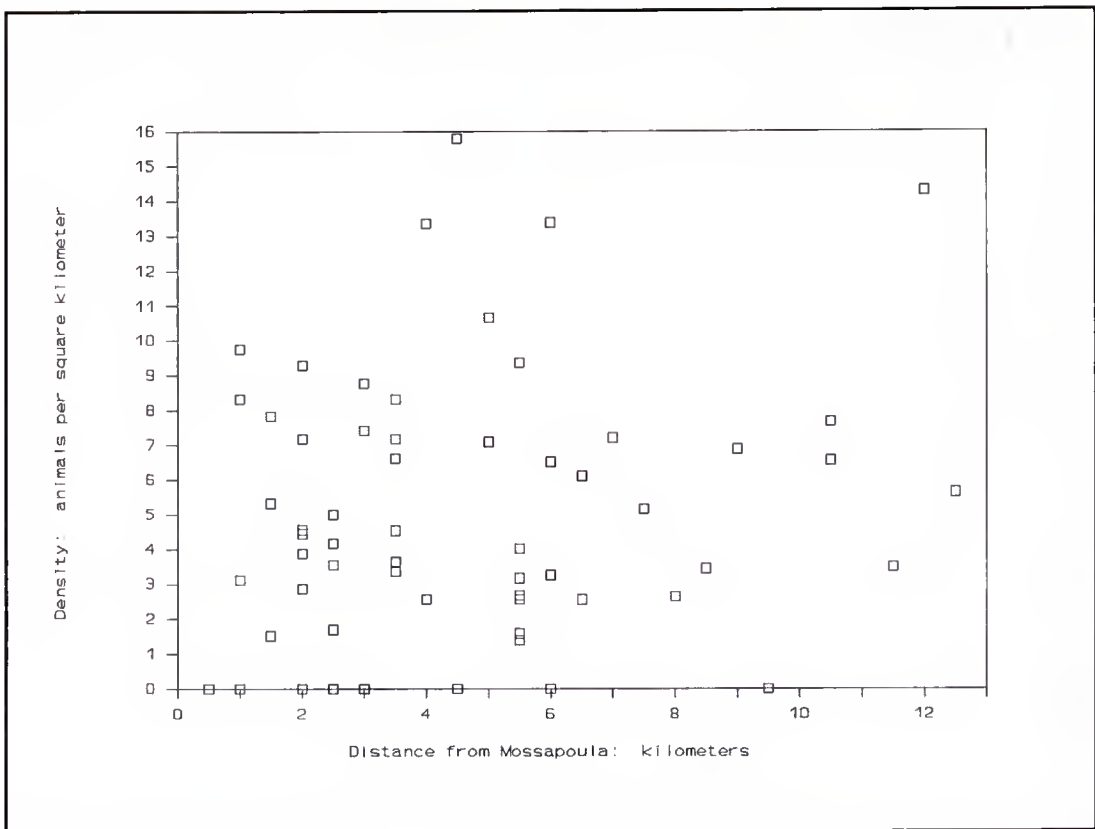


Figure 3.8: *A. africanus* Population Densities from Net Hunt Encounters (individuals per square kilometer, $N = 61$ net hunts).

Notes: $r_s = 0.247$, $p < 0.025$.

Data are the mean D2 values, with one outlying value excluded: $D = 24.96$ for a hunt 10 kilometers from Mossapoula.

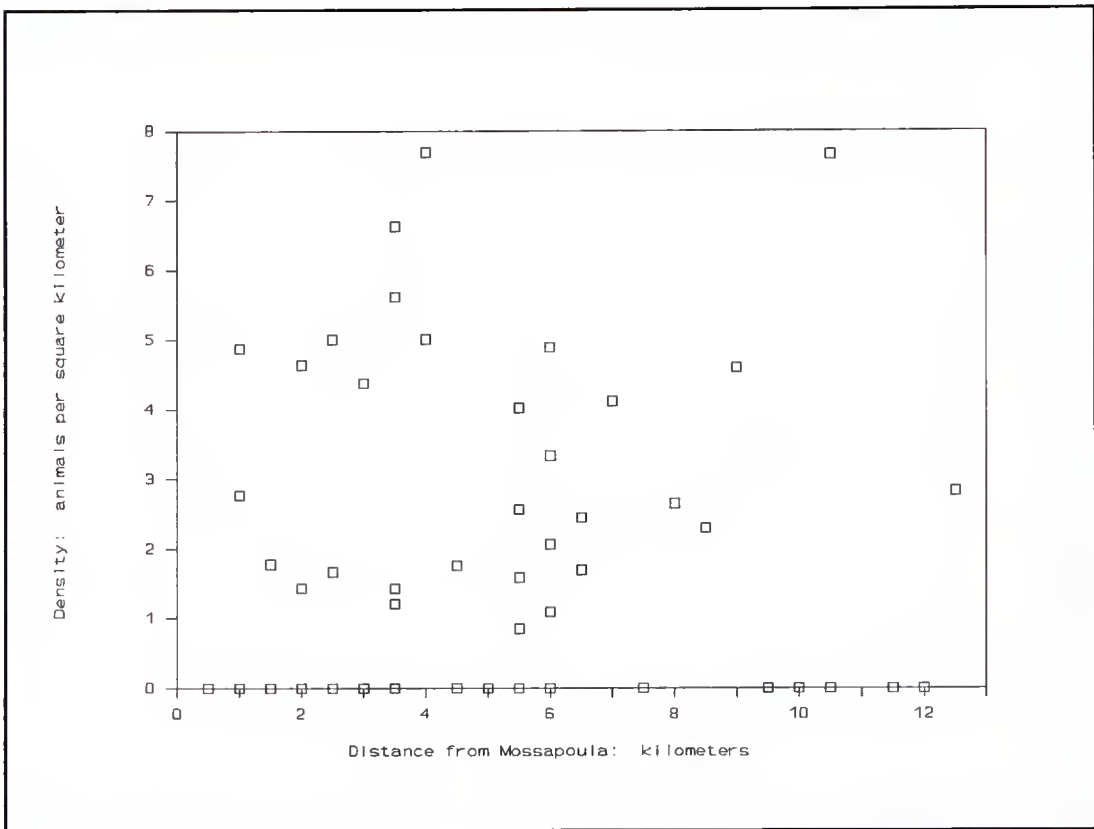


Figure 3.9: *C. callipygus* Population Densities from Net Hunt Encounters (individuals per square kilometer, $N = 61$ net hunts).

Note: $r_s = 0.246$, $p < 0.025$.
Data are the mean D2 values.

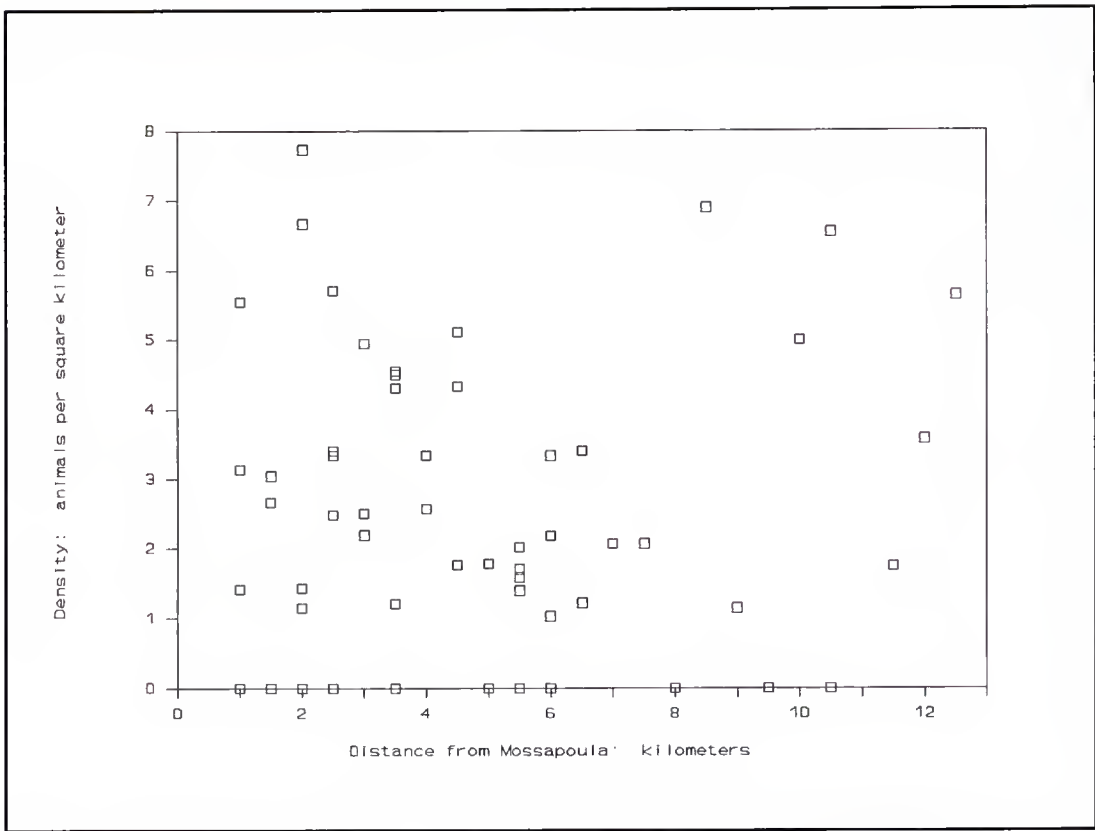


Figure 3.10: *C. dorsalis* Population Densities from Net Hunt Encounters (individuals per square kilometer, $N = 61$ net hunts).

Notes: $r_s = 0.106$, $p > 0.2$.

Data are the mean D2 values, with one outlying value excluded: $D = 28.71$ for a hunt 0.5 kilometers from Mossapoula.

Hunting pressure from net hunters declines as distance from Mossapoula increases. But total hunting pressure, including guns and snares, may be higher in areas some distance away from Mossapoula.¹⁰ There are no unhunted areas in the Bayanga region. Snares and guns target

¹⁰Gun and snare hunters may prefer to hunt further away from Bayanga where surveillance by game guards is lower.

proportionally more larger duikers, perhaps resulting in lower population densities of *C. callipygus* and *C. dorsalis* more than 5 kilometers from Mossapoula. However, *C. dorsalis* densities are inexplicably lowest in the 5-10 kilometer range, and may be incorrect.

Line transect versus net hunt encounter density estimates

Six net hunts took place in the line transect survey area, and here the two methods for calculating population densities can be compared (Table 3.6).

Table 3.6: Comparative Density Estimates:
Line Transects versus Net Hunt Encounters in a Single Area
(individuals/km²)

	<u>Line transect</u>		<u>Net hunt encounters</u>			
	<u>N</u>	<u>D</u>	<u>N1</u>	<u>D1</u>	<u>N2</u>	<u>D2</u>
<i>C. monticola</i>	33	10.5-18.8	36	78.9	44	10.6-33.2
<i>A. africanus</i>	--	--	13	28.5	13	3.1-9.8
<i>C. dorsalis</i>	1	0.3	6	13.1	8	1.9-6.0
<i>C. callipygus</i>	4	0.9-1.1	3	6.6	5	1.2-3.8

Notes: N = number of animals

D = estimated population density

Data are from 22 line transect surveys and 6 net hunts.

A Mann-Whitney U test comparing line transect to net hunt encounter density estimates find that the two methods produce significantly different results except in the case of minimum *C. monticola* density estimates.

	<u>Minimum D and D2</u>			<u>Maximum D and D2</u>		
	<u>U</u>	<u>Z</u>	<u>p</u>	<u>U</u>	<u>Z</u>	<u>p</u>
<i>C. monticola</i>	54	-0.69	0.221	35	-1.74	0.003
<i>C. dorsalis</i>	24	-2.18	0.015	47	-2.35	0.011
<i>C. callipygus</i>	41	-1.40	0.081	34	-1.79	0.037

The first density estimate from net hunt encounters appears to be a gross overestimate. The second density estimate approaches estimates from the line transect survey only in the cases of *C. callipygus* and *C. monticola*. Both methods

likely underestimate *C. callipygus* densities where hunting occurs, since this species is most likely to avoid detection by moving away from approaching humans. Net hunting density estimates for *C. dorsalis* are more likely to be accurate, because net hunters search more intensely than do line transect observers.

Table 3.7 presents the range of density estimates for the game species in the Bayanga region according to both census methods. In comparing the two methods for each species, the Mann-Whitney U test finds the variance between density estimates from line transect and net hunt surveys to be significant for *C. callipygus* ($U = 41$, $p < 0.08$) and for *C. dorsalis* ($U = 27$, $p < 0.015$).¹¹ The density estimates for *C. monticola* are statistically different if the maximum values by each method are compared ($U = 35$, $p < 0.01$), but not if the minimum values are compared ($U = 54$, $p > 0.22$).

Table 3.7: Population Densities of Game Species
in the Bayanga Region and Elsewhere
(individuals per square kilometer)

	<u>Bayanga</u>	<u>Other</u>
<i>C. monticola</i>	10.5-66.9	14.9-78.0
<i>A. africanus</i>	2.7-17.6	12.0-77.7
<i>C. dorsalis</i>	0.3-6.6	1.5-8.7
<i>C. callipygus</i>	0.9-3.7	0.6-15.5

Notes: Bayanga data are the full range of line transect and net hunt encounter density estimates given in Tables 3.4 and 3.5. Other data are given in Table 3.2.

¹¹However, the line transects recorded only one *C. dorsalis*.

The D line transect and the D2 net hunt encounter density estimates are used in later chapters to evaluate the sustainability of harvests by cable snare hunters and communal net hunters. However, a comparison of density estimates suggests that *A. africanus* densities are usually greater at other sites than those recorded in the Bayanga region. *C. callipygus* densities may possibly be underestimated by my censuses. It is also possible that real differences may exist between sites: higher hunting pressure may have reduced actual densities for all species in the Bayanga region, or habitat conditions may support larger numbers of animals in other census sites. Therefore, the density estimates should be used cautiously and conservatively.

The Human System

Ecosystem characteristics and processes in the Bayanga region are closely linked with the human system. This section examines the history of political, economic, and social influences that have produced the current regional human system. Political authorities have generally remained distant, but have strongly influenced economic activities in the region by granting resource exploitation rights to numerous international companies. The actions of these companies are primarily responsible for human settlement and mobility patterns in the region.

Political History

Administration of the Bayanga region has changed among several authorities in the past century, although the Bayanga region remains relatively isolated from political authorities in Bangui and beyond. Travelling up the Sangha river in 1892, De Brazza claimed the east bank of the Sangha river for France's Congo colony, while Germany claimed the west bank as part of Kamerun. In 1911 the French gave a portion of territory east of the Sangha including Bayanga to Germany in exchange for part of Morocco, but regained control over both sides of the river to the current Cameroon border at the end of World War I. In 1910 Congo joined with Chad, Gabon, and Oubangui-Chari to form French Equatorial Africa. In 1950 France transferred the Bayanga region from the Congo to the Oubangui-Chari colony (Sautter, 1966; Serre, 1960).

Oubangui-Chari became the independent Central African Republic in 1960, although the French retained a strong presence--exchanging financial and technical support, including several hundred technical assistants and most civil service salaries, for the right to maintain military bases in Bouar and Bangui.¹² France has also helped to enthrone and depose leaders on several occasions, for example Emperor Jean Bedel Bokassa (Kalck, 1993; O'Toole,

¹²France has launched military and relief operations from these bases into Chad in the 1980s and Rwanda in 1994.

1986). The first multi-party elections were held in 1992, but were annulled by President André Kolingba. Under strong international pressure, elections were held again in 1993, and Kolingba ceded power to the election winner Ange-Félix Patassé. However, the departing Kolingba government owed 10 months back-pay to all civil servants, and schools had been closed for three years by student and teacher strikes and the lack of funding. During the 1992 and 1993, while international donors tried to force democratic elections, most international development assistance to CAR was withheld.

However, political authorities only indirectly affect the Bayanga region. Laws regarding taxation, mobility, settlement, resource use, and conservation are only weakly enforced. Although President Kolingba declared them "citizens" in 1989, most BaAka residents are not allowed to vote because they lack birth certificates or identification cards (Kretsinger, 1993). While political authorities have changed, patterns of land use remain the same: all land and resources belong to the state, which allocates concession rights allowing various international companies to exploit particular resources. In turn, these companies are primarily responsible for providing services to the population, including roads, education, and health care.

Economic and Social History

Economic agents have been much more important than political actors in driving ecological and socioeconomic change in the Bayanga region. These actors have been principally foreign--concession companies, commercial societies, logging companies, and conservation organizations--and focus primarily on the exploitation of natural resources. Current economic activities with links outside the region include coffee plantations, logging, diamond mining, a conservation project, and safari hunting. Only coffee plantations and diamond mines are owned and operated by local residents.

Precolonial inhabitants of the Bayanga region were the Mbimu, Ngundi and Sangha-Sangha peoples, who fished along the Sangha river; and the BaAka, who hunted the forests east of the Sangha into what is today Congo (Demesse, 1978). Historical accounts suggest that, long before the first Europeans visited the area in the 1890s, the Sangha river was an important trade conduit for slaves, ivory, wild rubber,¹³ palm nuts, manioc, and dried fish (Harms, 1981; Kalck, 1993; O'Toole, 1986; Sautter, 1966).¹⁴ The economic history of the Bayanga region since 1900 is one of boom-and-

¹³Central African wild rubber comes from the vine *Landolphia owariensis*.

¹⁴The Portuguese began trading along the coast of central Africa by 1500, the Dutch by 1594, the French and British by the 1680s (Vansina, 1983; 1990).

bust cycles, as a series of foreign enterprises have brought temporary economic prosperity followed by collapse and stagnation (Kretsinger, 1993). Social history reflects these economic patterns, with population centers growing and declining as people seeking economic opportunities migrate in and out of the region.

Concession system

In order to exploit its colonial territories in central Africa (including what is today CAR), France adopted the Belgian Congo model of the concessionary system in 1898. Forty concession companies were formed, including the Société de la Kadeï-Sangha (12,900 km²) and the Compagnie des Produits de la Sanga Lipa-Ouessou (18,000 km²) in the Bayanga region. Through mechanisms of forced labor, a head tax which could be paid in forest products, and trade, these companies earned most of their profits from the extraction of ivory and wild rubber (Colchester, 1993; Coquery-Vidrovitch, 1972; Coquery-Vidrovitch and Moniot, 1974; Kalck, 1971; 1993; O'Toole, 1986; Serre, 1960; Zoctizoum, 1983). Under German administration the Compagnie Forestière Sangha-Oubangui used Bayanga as a base for extracting ivory, wild rubber, animal skins, and palm nuts (Carroll, nd.). In the 1920s the European fashion for fur gloves and coats made blue duiker skins a valuable commodity that the concessions extracted as well. During this period the BaAka were the principal forest product extractors, turning over ivory,

duiker skins, rubber and palm nuts to Bilo "patrons"

(Bahuchet and Guillaume, 1982; Ballif, 1954; Demesse, 1957; Hewlett, 1991; Sautter, 1966).

Coffee plantations

The concession companies were replaced in the 1930s by commercial societies based on agricultural production, but which continued to extract forest products. Two societies were established in Lindjombo, 30 kilometers south of Bayanga. Beginning in 1926 and 1931 respectively, the Santini and Lopez societies initially exploited rubber but soon established commercial plantations of coffee. Other societies operated around Salo, 50 kilometers north of Bayanga. Coffee plantations drew the first Gbaya and Mbimu immigrants to the Bayanga region from elsewhere in CAR, as well as additional BaAka migrants from the Mokala watershed to the east in Congo (Giles-Vernick, in progress; Kretsinger, 1993).

In addition, the societies benefitted from collective farms required by colonial administrators of all villages: one coffee farm for export production, and one food crop farm to pay village taxes. Residents were required to provide labor for both farms (Kalck, 1971; Zoctizoum, 1983). The societies did not leave the Salo area until 1967, and the Lindjombo area until 1980. Local residents also began to grow coffee as a cash crop before the societies left. Despite declining prices, local farmers continued to

cultivate coffee, including small farms around Bayanga after 1972, until the CAR coffee marketing board went bankrupt in the early 1990s (Giles-Vernick, in progress). Collection and payment resumed in 1994, and farmers are once again maintaining and harvesting their coffee.

Logging

In 1971, the government awarded concession rights in the Bayanga region to the Yugoslav company Slovenia-Bois. With the construction of a sawmill in Bayanga and the commencement of logging activities in 1972, immigration induced by employment opportunities increased Bayanga's population from several dozen to approximately 5,000 people. The lumber boom years were seen by Bayanga residents as "paradise". Slovenia-Bois provided many benefits directly: employment, health services, schools, and housing. In addition, the cash incomes, combined with well-maintained road and river transportation networks, generated a great deal of secondary employment. From 1972 to 1986, 1,000 square kilometers of forest were selectively logged.

However, poor management, changes in world timber prices, and competition from logging companies in Congo and Cameroon¹⁵ caused Slovenia-Bois to go bankrupt in 1986. The abrupt closing left all employees jobless, with several months of back-pay outstanding. Many stayed in Bayanga,

¹⁵These countries exploit the same tree species but have lower transportation costs than does land-locked CAR, which must export timber through Congo or Cameroon.

waiting for their back-pay and for logging to resume. In 1988 logging resumed briefly under new management, French-owned Sangha-Bois. But the CAR government shut down the company in 1990 for not meeting its obligations to pay outstanding taxes and back salaries (Telesis, 1991).

In 1993 a third (French) company began logging operations in Bayanga, eventually renaming itself Sylvicole de Bayanga. To date, approximately 100 of Slovenia's 600 peak full-time employees have been rehired. Working the original Slovenia concession east and north of Bayanga until August 1994, Sylvicole de Bayanga obtained a new logging concession south and west of Bayanga in September 1994. The new concession, perhaps obtained with French government assistance, preempted an effort by the German government and WWF to buy out logging rights in the region in order to consolidate conservation efforts. At about the same time, Sylvicole de Bayanga at last paid outstanding back salaries.

A separate logging concession in the northwestern portion of the reserve has been exploited since 1990 by the French company SESAM, based in Salo (Giles-Vernick, in progress). Figure 3.11 shows areas that have been logged, or where logging is currently taking place, in the Bayanga region.

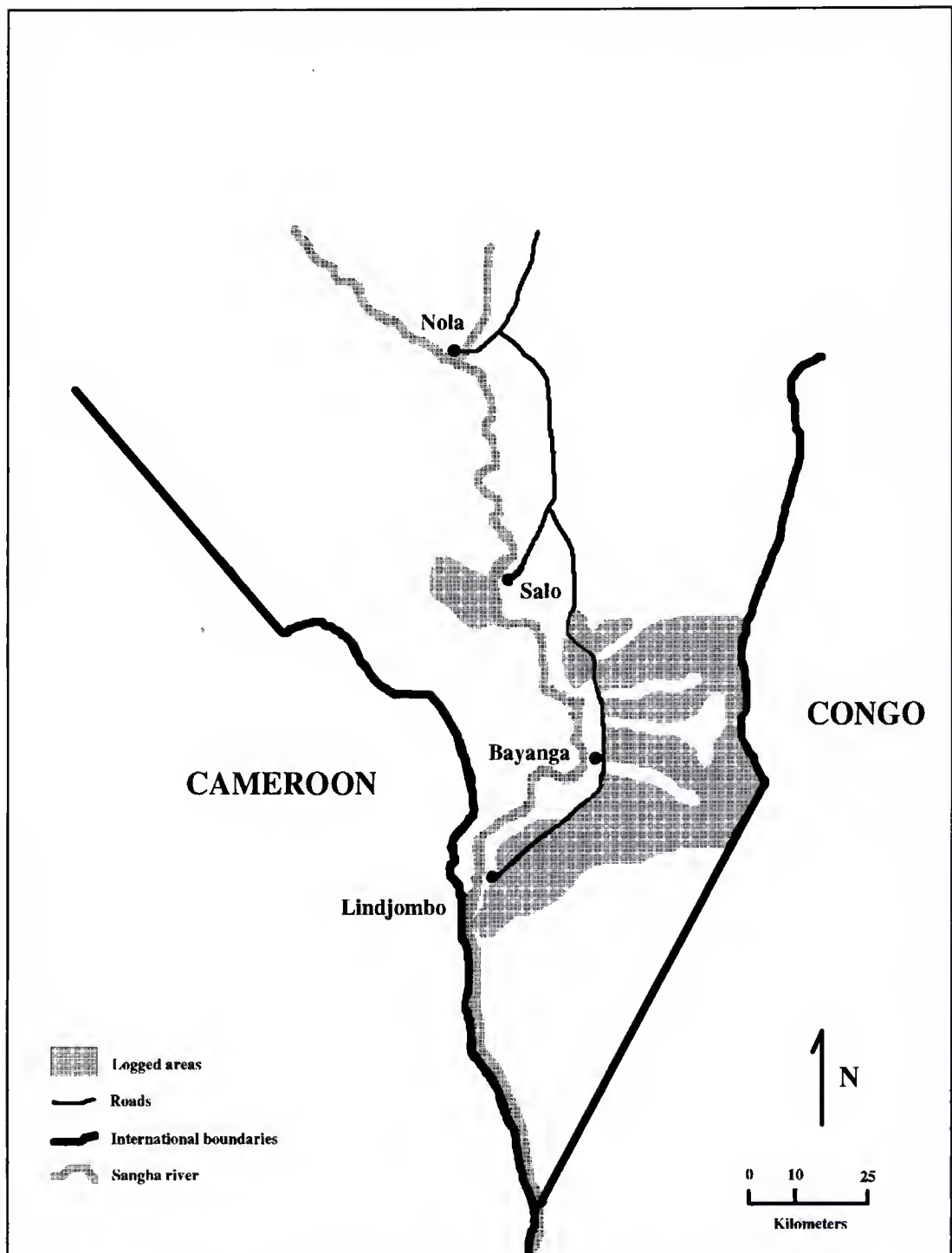


Figure 3.11: Logging in the Bayanga Region

Source: Carroll, 1986b.

Forestry exploitation has focused on only four species: the white woods *Triplochiton scleroxylon* and *Terminalia superba*, and the mahoganies *Entandrophragma cylindricum* and *Entandrophragma utile* (Carroll, 1986b).¹⁶ Harvest rates are extremely low, averaging less than one stem per hectare. Slovenia-Bois exported the white woods in the form of plywood, and the red woods as whole logs, by barge down the Sangha river to Brazzaville and from there to the coast by rail. Sylvicole de Bayanga is exporting white and red woods as whole logs by truck via Berberati to the port of Douala in Cameroon.

Diamond mining

Diamonds have surpassed coffee and timber as CAR's most important export (World Bank, 1990). The majority of diamonds are supplied by an estimated 50,000 artisanal producers who excavate pits several meters across and several meters deep in stream beds (Kalck, 1971; Zoctizoum, 1983). Exploitation areas have shifted gradually south from Carnot, which is located north of Berberati. In 1994 a concentration of over 2,000 people occupied a mining area on the northern boundary of the reserve itself near Yobé, only 20 kilometers from Bayanga, benefiting from the roads put in by Sylvicole de Bayanga's logging operations in the area. Most miners are immigrants from outside the Bayanga region,

¹⁶These timber species are known commercially as Ayous, Limba, Sapeli and Sipo respectively.

but a number of Bayanga and Mossapoula residents now participate as well, as miners, porters, or merchants supplying food and commodities. In October 1994, there were four BaAka camps at the Yobé site: one group from Nguenguéli net hunting to provision the miners, one group from Nguenguéli and Belamboke exploiting its own claims, and two groups from Koundapapaye and Nguenguéli working as porters.

Integrated conservation and development

The Dzanga-Sangha integrated conservation and development project (Figure 3.12) was established with the creation of the Dzanga-Ndoki National Park and the Dzanga-Sangha Special Reserve in 1990 by the government of CAR (République Centrafricaine, 1992a; 1992b). "The project" is headquartered in Bayanga. Principal external donors have been WWF, the World Bank, and the United States Agency for International Development (USAID). The project has multiple conservation objectives: to protect important populations of forest elephants, lowland gorillas, and other wildlife; to preserve a significant portion of CAR's remaining rain forest; and to maintain the cultural integrity of the BaAka Pygmies who depend to a large extent on hunting and gathering forest products (Carroll, 1986b; Doungoubé, 1990).

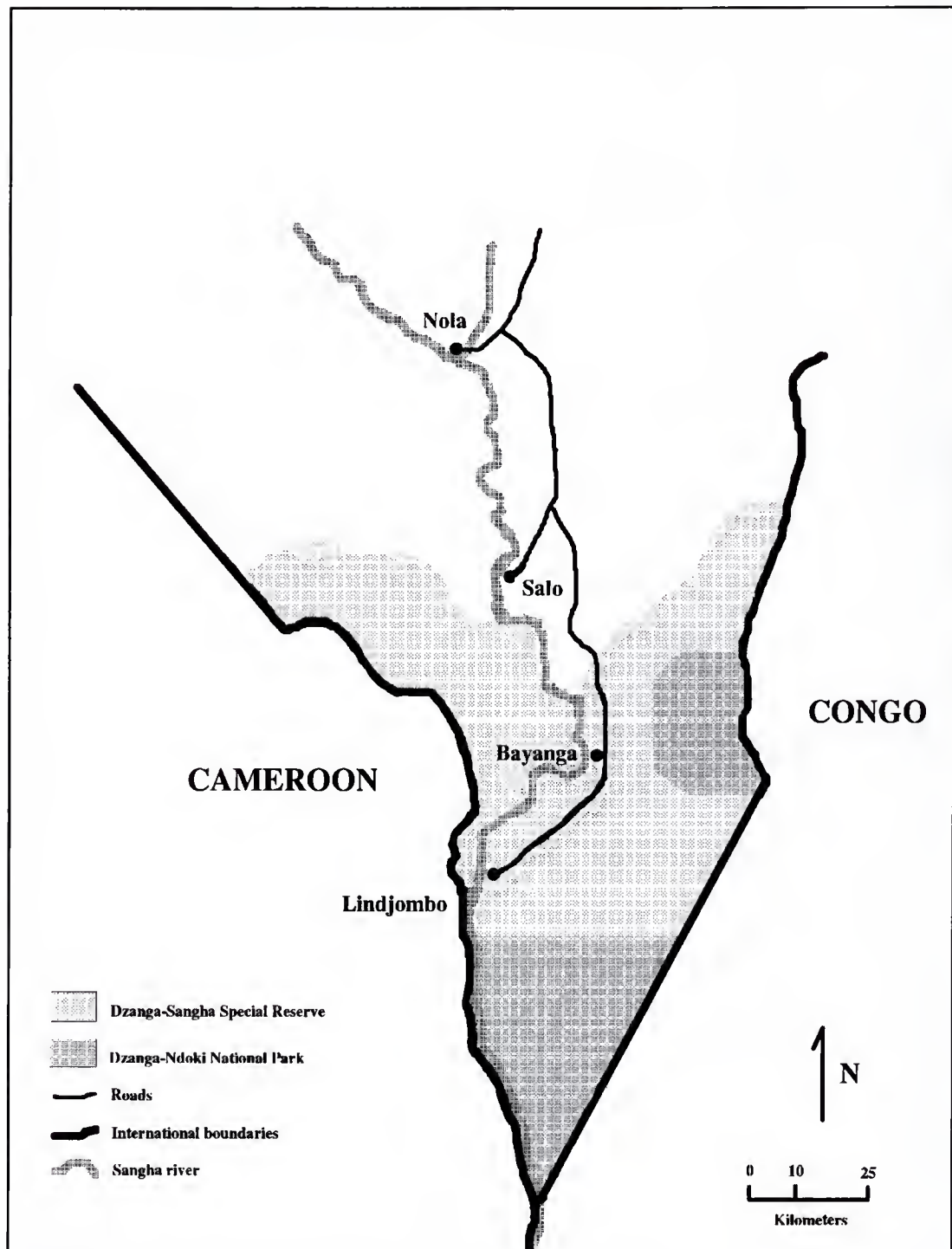


Figure 3.12: Dzanga-Ndoki National Park and Dzanga-Sangha Special Reserve

Source: Doungoubé, 1990.

The project includes the following conservation components: the Dzanga-Ndoki National Park comprising two core protected areas totalling 1,220 square kilometers, anti-poaching measures, tourism promotion to generate revenues, and conservation education. In order to reinforce its conservation objectives, the project also incorporates rural development components: most importantly health care services, as well as employment in park protection and tourism-related activities. Furthermore, the project permits certain subsistence and income-generating activities within the 3,360 square kilometer Dzanga-Sangha Special Reserve: farming in a kilometer-wide strip along the main Lindjombo-Salo road, selective logging, safari hunting, and subsistence hunting and gathering using traditional harvest methods (Carroll, 1986b; Doungoubé, 1990; EIL, nd.; République Centrafricaine, 1992b).

The project also promotes tourism in order to generate income for community development: forty percent of park visitor fees are reserved for community development. An initial community development association formed to distribute these funds to individuals and groups for small business ventures collapsed in 1992. A second association of 60 representatives from the entire project area was formed in 1994 to identify and implement community development activities.

Tourism has grown slowly, to roughly 100 visitors per month in 1994. Tourism is constrained by the lack of lodging facilities in Bayanga, and CAR's poor transportation infrastructure. Tourists are mainly expatriates working in CAR and French military personnel (Telesis, 1991).

Virtually all visit the Dzanga bai, while a few hire project guides for excursions in the forest to visit other baïs or to track gorillas; on the Sangha river to tap wine from raffia palms; or on BaAka hunting or gathering trips.

Safari hunting

The Lefol safari company has offered luxury safari hunting in Bayanga since 1986. Hunting focuses almost exclusively on bongo antelope, since Bayanga is one of the few locations in the world where this species can be hunted. Occasionally the hunters hunt other species, but with little success. Most hunters end their visit immediately after collecting their bongo. Only male bongo are hunted. The company receives eight or ten clients per year, during a May-July hunting season, and exploits the north-eastern section of the Reserve. The project levies a 25,000 CFA (\$50) daily fee on the safari company for using the Reserve. Each client pays \$10-20,000 (5.7 to 11.4 million CFA) to the safari company for a 10-day safari, excluding CAR government taxes: hunting licenses costing roughly 300,000 CFA (\$600), and a trophy tax for each animal killed (500,000 CFA or \$1,000 for a bongo). The Bayanga mayor's office receives 40

percent of the trophy tax on behalf of the community (Telesis, 1991).

Exploitation versus conservation

Selective logging can be compatible with conservation and development, if logging is ecologically sustainable while it generates local employment and national revenues. The harvest rate of 0.8 trees per hectare was low (Carroll, 1986b; 1986c), and similar logging practices in Congo remove approximately 6.8 percent of canopy, including all roads and skidder trails (Wilkie et al., 1992). The ecosystem can probably recover from this level of damage. However, logging operations in CAR are poorly supervised, regulations regarding harvesting practices and requiring restoration or reforestation are rarely enforced, and many taxes and fees are unpaid (Colchester, 1993; Telesis, 1991).

In addition, relations between Sylvicole de Bayanga and the Dzanga-Sangha conservation project are antagonistic, particularly since the attempted buy-out was made public. Although cooperation and compromise could be possible, the logging company wants sole jurisdiction over the area, and incites the local population by saying the project wants to take away their jobs. Sylvicole de Bayanga does continue to maintain transportation networks in the area, most importantly the road north to Salo and the airstrip. Without these transportation networks other economic

activities in the area, including tourism and administration of the park project, would be virtually impossible.

Diamond mining as currently practiced is small-scale exploitation: most work is by hand, and the biggest capital investment only a few miners can make is in a gasoline-powered water pump. However, agglomerations of 2,000 people do not leave a forest intact. Trees are cut for settlements and mining operations, while river valleys are excavated. The hunting pressure surrounding mining areas is particularly intense, and extends into the Dzanga-Sangha Reserve, with professional full-time hunters supplying meat. Diamond mining is illegal in the Reserve, but prospectors are continuously moving south, and project authorities have already expelled several miners found inside the Reserve. As mining areas elsewhere in CAR are depleted, the project will face increasing pressure.

Safari hunting is a low-impact, high-return form of wildlife exploitation. However, the profits accrue mainly to the safari company or the CAR government. Those revenues paid to the mayor of Bayanga have financed his personal car. Safari hunting also provides few local jobs: most of the half-dozen trackers are hired from other villages north of Bayanga. Furthermore, little is known about bongo population abundance and ecology to determine the effects of harvesting eight adult males per year in the region.

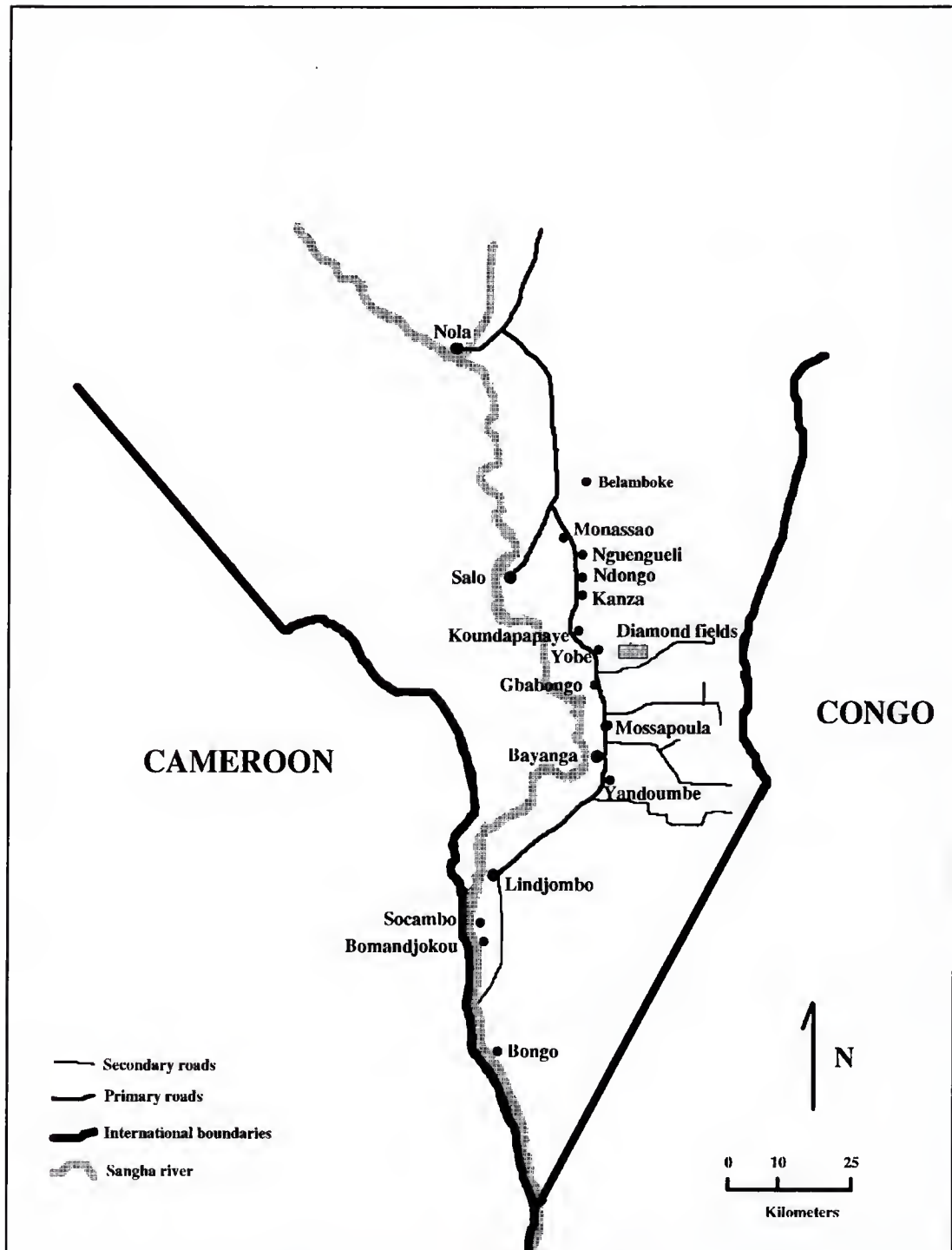


Figure 3.13: Population Centers in the Bayanga Region

Source: BSP, 1990; Carroll, 1986b.

Population Centers in the Bayanga Region

This section describes major population centers in the region including Bayanga, Lindjombo, and the BaAka Catholic mission center of Monassao/Nguengueli. Additional villages are situated along the main road: Yandoumbé, Mossapoula, Gbabongo, Yobé, Koundapapaye, Kanza and Ndongo. South of Lindjombo, on the east bank of the Sangha river, are the villages of Bomandjokou, Bongo, and Socambo (Table 3.8). A brief description of the settlements reveals a diverse range of economic strategies and patterns of inter-ethnic relations, according to the economic opportunities and constraints each settlement faces.¹⁷

Population density for the Bayanga region averages 0.5 persons per square kilometer (Carroll, 1988). Current population centers result primarily from intra- and extra-regional migration in response to economic opportunities: Bayanga, the largest town in the region, is the base for a logging company as well as a conservation project. Nola and Salo are also centers for diamond mining and logging companies. In recent decades, BaAka populations have migrated west into the Bayanga region from Congo. Immigrants of other ethnic groups (Banda, Bossangoa, Gbaya, Mbimu, etc.) originate mainly from elsewhere in CAR, though

¹⁷Such variation among neighboring villages has also been noted elsewhere in Africa (Althabe, 1965; Bahuchet, 1991; Bahuchet and Guillaume, 1982; Kent, 1992; Vierich, 1982).

a few come from neighboring countries such as Cameroon, Chad, and Congo.

Table 3.8: Estimated Population Figures for Settlements in the Bayanga Region (number of inhabitants)

<u>Settlement</u>	<u>BaAka</u>	<u>Bilo</u>	<u>Total</u>
Bayanga ^a	10	2,500	2,510
Monassao ^b	750		750
Lindjombo ^c	220	500	720
Nguengueli ^b	600		600
Mossapoula ^b	320	50	370
Yandoumbé ^d	320		320
Gbabongo ^d	60	150	210
Bomandjokou ^d	40	150	190
Socambo ^d	60	100	160
Ndongo ^b		85	85
Koundapapaye ^d	80		80
Bongo ^d		50	50
Kanza ^b		50	50
Yobé ^d	40	10	50
Total	2,500	3,645	6,145

Sources: ^aBayanga mayor's office census, 1994; ^bNoss censuses 1994; ^cGiles-Vernick, in progress; ^dKretsinger, 1993.

Bayanga

The original Kaka, Ngundi, and Sangha-Sangha inhabitants of Bayanga depended on fishing, while their BaAka neighbors hunted and gathered. Economic growth following the establishment of logging operations in 1972 brought large numbers of immigrants, and the BaAka moved to the nearby villages of Mossapoula and Yandoumbé (Doungoubé, 1990; WWF, 1991). Of the 838 adult inhabitants of Bayanga in 1991, only 15 percent were born in Bayanga (Table 3.9).

Table 3.9: Bayanga Population Origins

<u>Place of birth</u>	<u>Number</u>	<u>Percent</u>
Elsewhere in CAR	304	36.3
Nola	187	22.3
Berberati	170	20.3
Bayanga region	127	15.2
Salo	40	4.8
Other African countries	10	1.2
Total	838	100.0

Source: 1991 Presidential elections census.

Both residential and occupational mobility are high for Bayanga residents (Figure 3.14). Pursuing economic opportunities and exploiting extended family connections, Bayanga residents move to and from all parts of CAR, with some traveling as well to Cameroon, Chad, or Congo. Short-term occupational mobility (daily or weekly) emphasizes forest and river exploitation within the Bayanga region: hunting, fishing, raffia wine tapping, raffia shingle construction, diamond mining and logging. Bayanga residents also engage in trade activities along the Sangha river and the CAR road network as far as the borders with Cameroon, Chad and Congo.

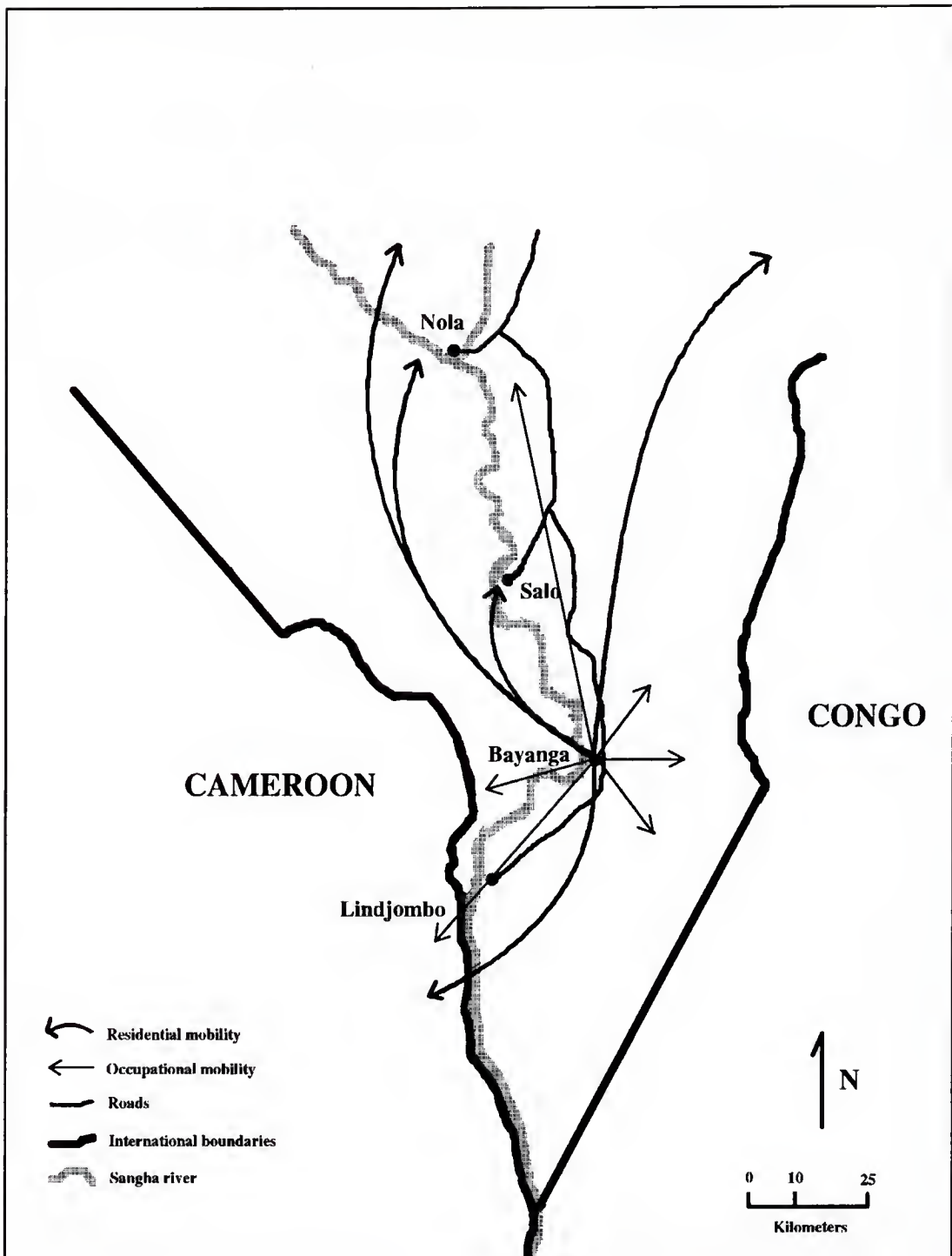


Figure 3.14: Bayanga Residential and Occupational Mobility

The 1994 mayor's office census for Bayanga counted 2,489 inhabitants, including several ethnic groups: BaAka, Banda, Bogongo, Gbaya, Kaka, Mbimu, Ngundi, and Sangha-Sangha. This population compares with roughly 5,000 during the 1970s timber boom years, and less than 2,000 during the years when logging was not taking place. The road south from Salo is maintained by the logging companies, so in periods when they are not active the road becomes nearly impassable, thus greatly reducing travel and trade.

Table 3.10 presents two snapshots in time of a highly dynamic employment situation.¹⁸ Many individuals combine more than one activity, for example fishing and tapping raffia wine, raffia shingle production and farming, or snare hunting and virtually any other activity. For example, an additional 27 individuals in Census B combine snare hunting with other activities, bringing the total number of active snare hunters to 94 (23.7 percent). Furthermore, individuals frequently switch among these activities as economic and ecological conditions change: the logging company and the project hire or lay off workers; an unsuccessful hunter tries his hand at fishing or diamond mining; or high water during the wet season floods the diamond pits and the miners return to farming or fishing. Therefore the employment distribution varies significantly

¹⁸The project also estimated in 1991 that 68 of 400 households (17 percent) engaged in snare hunting (Telesis, 1991).

by year, month, and even week. Between 1991 and 1994, the logging company replaced the park project as the most important employer, while snare hunting remained the second most important employment opportunity.

Table 3.10: Men's Employment in Bayanga
(number and percent of individuals by occupation)

	<u>Census A</u>		<u>Census B</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
Logging company	121	28.3	66	16.6
Snare hunting	85	19.9	67	16.9
Park project	76	17.8	119	30.0
Fishing	33	7.7	10	2.5
Other	32	8.1	--	--
Commerce	29	6.8	25	6.3
Government	28	6.5	9	2.3
Farming	23	5.4	43	10.8
Raffia wine tapping	21	4.9	4	1.0
Diamond mining	11	2.6	11	2.8
Raffia shingles	1	0.2	11	2.8
Total	428	100.0	397	100.0

Notes: Of the 498 men reported by Census B as living in Bayanga in 1991, 101 had moved away by 1994. The Dzanga-Sangha project also estimated in 1991 that 68 of 400 households engaged in snare hunting (Telesis, 1991).

Sources: Census A, 1994, Bayanga mayor's office. Census B, 1991, presidential elections registration.

The project has linked changes in logging company employment directly to the intensity of snare hunting (Doungoubé, 1990; Hunsicker and Ngambesso, 1993; Telesis, 1991; WWF, 1991). Snare hunter informants identified over 150 individuals from the 1991 census (498 men in total) who had at one time or another hunted with snares. By 1994 Sylvicole de Bayanga had only rehired 33 of these individuals. The rest continued to snare hunt, pursued

other activities in Bayanga, or emigrated to seek work elsewhere: by 1994, 101 had moved away from Bayanga. Workers laid off by the project also often take up snare hunting. But snare hunting is not the only viable economic alternative. The project estimates that in Bayanga's economy, the value of raffia wine sales and raffia shingle exports equal the contributions by each of the two formal employers: the logging company and the project.¹⁹

Mossapoula

Before Slovenia-Bois opened in 1971, the Mossapoula BaAka lived next to the Kaka fishing village of Mbinjo, which is now part of Bayanga. By the early 1980s most of the BaAka had moved to the airstrip and worked for the logging company. They moved five kilometers north of Bayanga to their present location at Mossapoula in the mid-1980s.²⁰ Some of their Kaka patrons moved with them (Kretsinger, 1993).

Most BaAka have their own manioc fields, but have been discouraged from expanding cultivation because of elephant damage. Men find formal employment with the logging company, the project, and researchers. Both men and women

¹⁹The employment figures therefore underestimate participation in these two activities, perhaps because most individuals combine raffia wine tapping or raffia shingle construction with other activities, and cite the other as their principal occupation.

²⁰Reasons cited for the move were problems with Bilos, insufficient land for manioc fields, and the water source was too distant.

also work as day laborers for Bilos in Bayanga and occasionally in Mossapoula or Gbabongo. Men at times also make raffia roof shingles, and tap raffia wine.²¹ Net hunting is practiced year-round on day hunts from Mossapoula, and from forest hunting camps. No group stayed in the forest for more than two months in 1994, but in 1993 one group was away for ten months. The Mossapoula Bilos cultivate, fish, hunt, tap wine from raffia palms, and make roof shingles. Every evening a group of Bayanga market women, varying in number from 2-30, visits Mossapoula to sell bread, manioc, alcohol, peanut butter, and other goods. In return they buy meat, "koko" leaves (*Gnetum buckholzianum*), "payo" nuts (*Irvingia excelsa*), mushrooms,²² and occasionally manioc.

I conducted two censuses of the BaAka population of Mossapoula, the first on September 14, 1993; the second on November 21, 1994 (Figure 3.15). At each house I asked the name of the man and/or the woman who occupied the house, and the number of children who slept there. Houses that were empty because their owners were temporarily away from Mossapoula were included. "Children" were defined to be

²¹However, they complain that tapping raffia wine requires too much time and interferes with other activities: trees must be visited twice a day. Furthermore, their neighbors often steal wine from the tree.

²²Over two dozen species are edible, but the three species marketed most commonly are called "musele", "banyavya", and "tokomba" in BaAka. The scientific names are not known.

those still living with their parents, whereas adolescents who did not live with their parents were counted as adults, but could have been missed because they sleep in same-sex group houses. A WWF health census in 1992 counted 316 BaAka residents (Table 3.11).²³

Table 3.11: Mossapoula Censuses
(number of residents)

	<u>1992^a</u>	<u>1993^b</u>	<u>1994^c</u>
Adults	156	122	158
Men		58	73
Women		64	85
Children	160	133	162
Total	316	225	320

Sources: ^aKretsinger, 1993; ^b, ^cNoss censuses.

The village is constantly changing, as individuals and families frequently move, to temporary hunting camps in the forest, to the diamond fields, or to other villages where they have relatives: from Bomandjokou in the south to Belamboke in the north. Within the village, frequent shifts take place as well, most significantly in 1994 the relocation of four families from the main village north of the Mossapoula river to an independent site half a kilometer to the south.²⁴

²³Anna Kretsinger and Victor Bavon.

²⁴This move was attributed to a conflict over land: their houses were on land someone else claimed as his field.

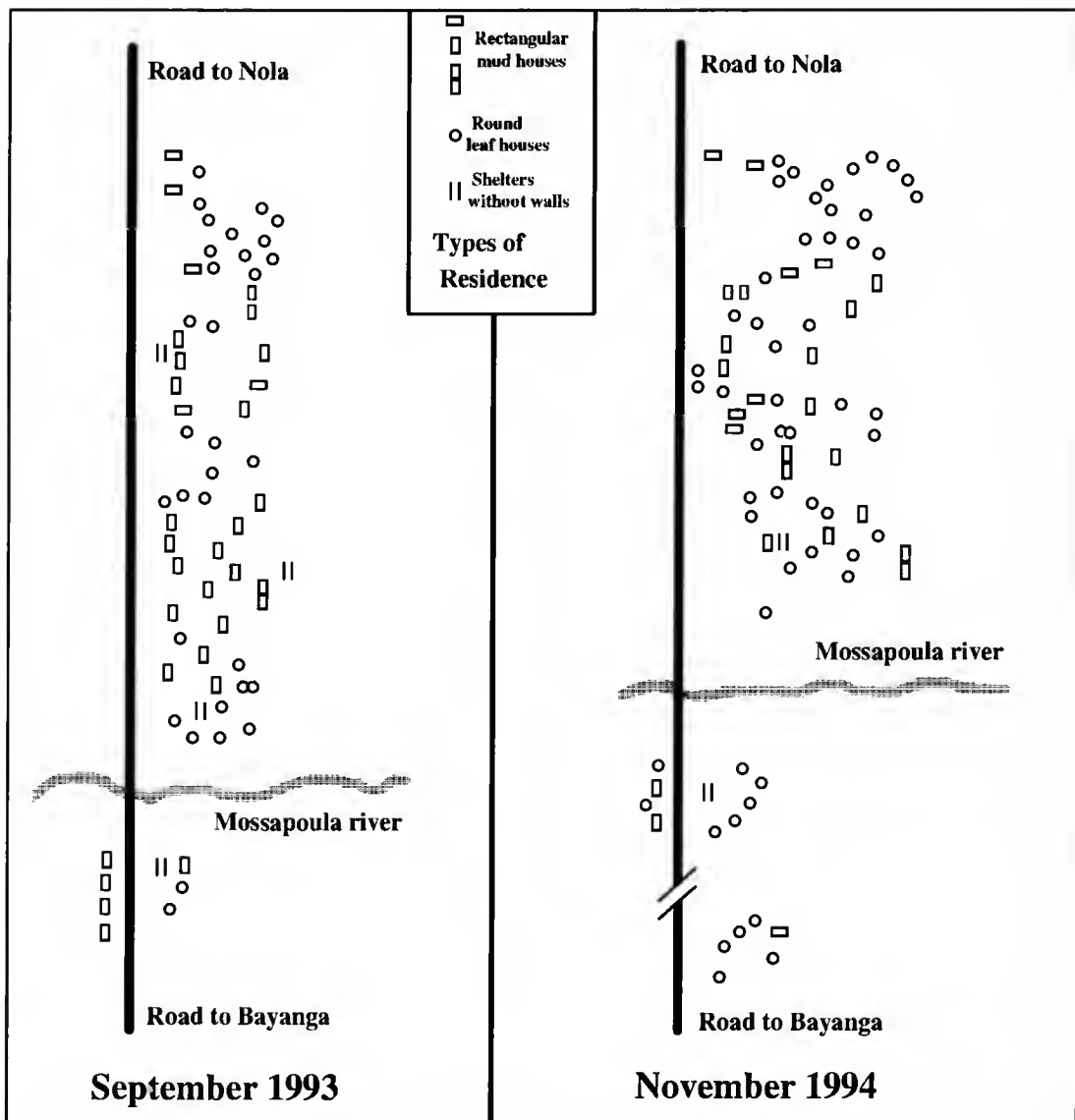


Figure 3.15: Mossapoula Censuses: September, 1993 and November, 1994

Mossapoula residential and occupational mobility occur on a smaller scale than is the case for Bayanga residents (Figure 3.16).

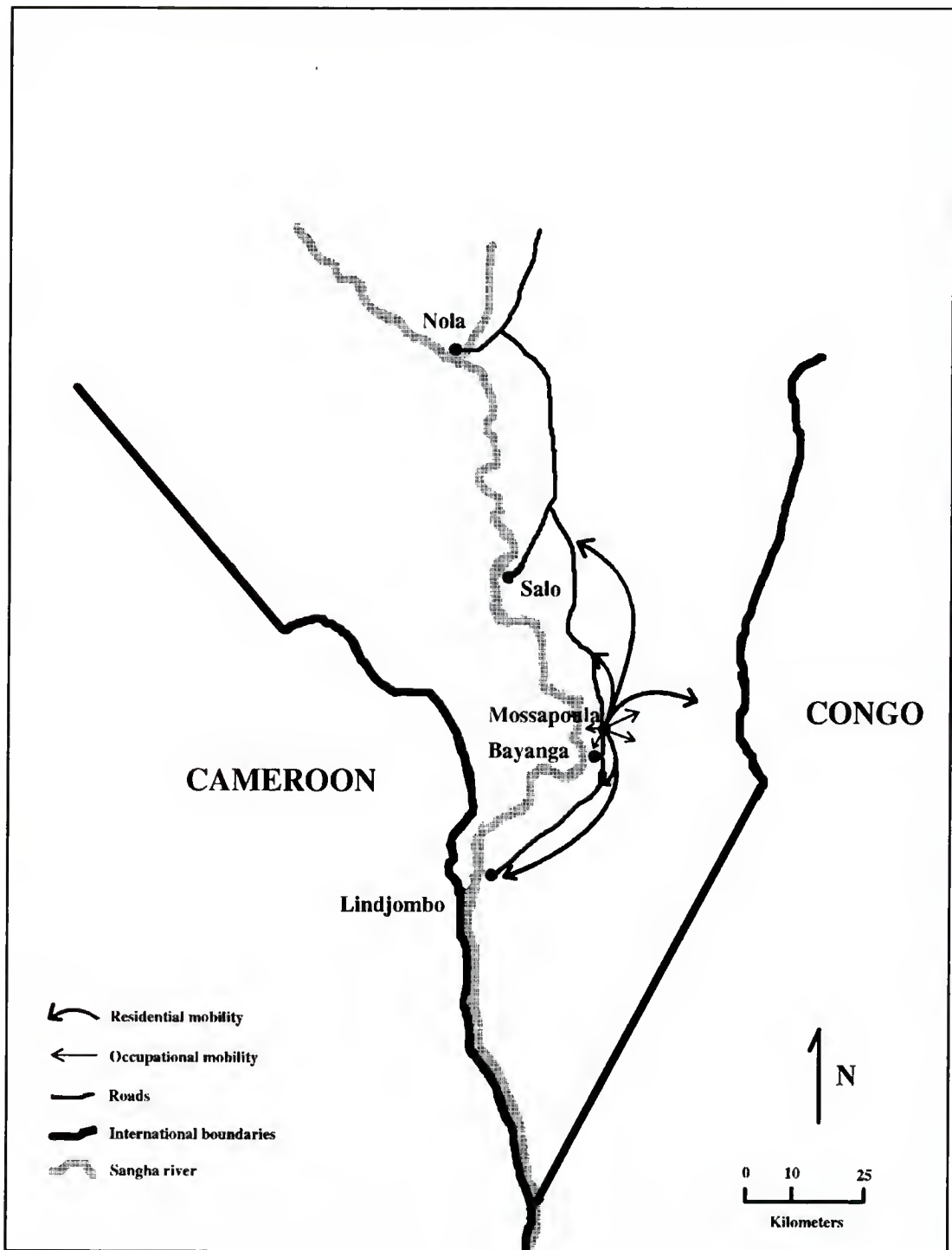


Figure 3.16: Mossapoula Residential and Occupational Mobility

Residential mobility takes place along two axes: a north-south axis between Mossapoula and other villages, and an east-west axis between Mossapoula and forest hunting camps. People change residences because of conflicts with their neighbors, in order to visit family members living elsewhere, and to pursue economic opportunities elsewhere, such as logging, diamond mining, and farming. Occupational mobility focuses on wage-labor opportunities in other settlements, especially Bayanga, or on forest exploitation: hunting, gathering, fishing, logging, conservation, research, and diamond mining.

Other settlements

With my assistants I visited the other settlements in the Bayanga region during two week-long trips: north of Bayanga by road in October 1994, and south of Bayanga by road and river in November 1994.

Bomandjokou, Bongo, and Socambo. The Bilos work across the river in Cameroon in the logging town of Libongo, or sell dried fish.²⁵ Several individuals snare hunt. Some Bilos have moved south from Lindjombo to Bongo and Socambo in order to fish and cultivate, occasionally accompanied by some of their BaAka "clients" (Kretsinger, 1993). The BaAka net hunt infrequently, and did not establish any forest camps in 1994. Few have fields, and most work for Bilos.

²⁵Dried fish from this portion of the Sangha is transported and sold as far away as Nola, 150 kilometers to the north, and Ouesso, 150 kilometers to the south in Congo.

Gbabongo. The Bilos cultivate manioc and maize, hunt with snares and guns, make raffia palm shingles, and mine diamonds. Their location on the main road, 10 kilometers north of Bayanga and somewhat removed from the project's surveillance, enables them to sell food crops, bushmeat and raffia shingles both to Bayanga and to vehicles traveling north to Nola and Berberati. The BaAka are exploited and even physically abused by the Gbabongo Bilos. Some have left, but those who remain work their "patrons'" fields, diamond mines, and snare lines. They have very few fields of their own and depend mainly on Bilo food crops, net hunting only occasionally (Kretsinger, 1993). Though they did not make forest camps in 1994, they did form joint forest camps with Mossapoula groups in 1993.

Kanza and Ndongo. Residents are farmers and diamond miners.

Koundapapaye. The BaAka in Koundapapaye left Yobé in 1990 to create a BaAka-only village, and are self-sufficient in manioc. However, they continue to work intermittently for Bilos in order to earn cash. Bilos have recently moved to the Koundapapaye area as well, saying that elephant damage to their fields near Bayanga is too severe. They now occupy land both north and south of the BaAka village, in effect recapturing BaAka labor, and recreating competition for land and ethnic conflicts that the BaAka originally fled in establishing Koundapapaye. The BaAka hunt with nets and

with snares, but just on day trips from the village, and not from forest camps. When Slovenia-Bois was logging the surrounding area in the 1970s, several of the men worked for the company.

Lindjombo. A "dead" town following the decline of coffee plantations and the closure of the logging company across the Sangha river in the Cameroonian town of Bela, the Bilos who remain fish and cultivate (Giles-Vernick, in progress). In the 1950s, the BaAka worked in coffee plantations and cultivated manioc farms. At that time they did not net hunt, and entered the forest only to hunt elephants (Demesse, 1957; 1980). Many BaAka today have small fields, but are not self-sufficient in manioc and often work in their Bilo neighbors' coffee plantations or manioc fields. The Lindjombo BaAka are not a cohesive social unit, and several separate net hunting and spear hunting groups established forest camps in 1994, with one group staying in the forest for over four months.

Monassao and Nguengueli. Established by a French priest in 1975 to foster socio-economic development for the BaAka (Carroll, nd.; Koulaninga, 1987), Monassao drew BaAka migrants from as far as Bambio (120 kms to the northeast). As Monassao has grown, some residents have moved a short distance south to form the village of Nguengueli. Catholic missionaries continue to promote manioc cultivation and processing, to provide primary education and adult literacy

programs as well as health services, and to encourage social and political awareness through voter registration and equal treatment of the BaAka.²⁶ Though the villages are located in a savanna area, residents continue to net and snare hunt in nearby forests, while hunting occasionally for cane rats (*Thryonomys* sp.) in the savannas with dogs or snares. In the dry season some groups move to forest hunting camps for months at a time. In 1994, net and crossbow hunters in forest camps were supplying meat to the diamond fields near Yobé and further north. They also produce manioc for consumption and sale. Finally, many individuals now work in the nearby diamond fields, mining their own claims or serving as porters for Bilo miners and merchants.

Yandoumbé. Originally living next to the Sangha-Sangha in Bayanga, the Yandoumbé BaAka moved to the Kenié river next to the Slovenia-Bois sawmill in the mid-1970s. At this site the BaAka suffered tremendously from disease, alcoholism, and abuse from Bilo creditors. The American musicologist Louis Sarno, living with the BaAka since 1986, persuaded them in 1990 to move to the current village site three kilometers south of Bayanga (Kretsinger, 1993; Sarno, 1993). Most now cultivate and have at times sold manioc to Bayanga residents. Two dozen men work for the logging

²⁶In 1994, with some encouragement from the missionaries, the Monassao BaAka went on strike against Bilo employers and merchants on two occasions: for higher porter wages, and for higher manioc prices. Both strikes were successful.

company, and others work for researchers and the project. Men and women also work as day laborers for Bilos in Bayanga. In 1994, the village split into three sections, with two groups moving one kilometer closer to Bayanga. In order to study and record BaAka music, Sarno periodically encourages a group to establish a hunting camp in the forest where the hunting is better and the distractions are fewer. At least three other spear hunting²⁷ and net hunting groups established independent forest camps in 1994, until a death in Yandoumbé brought them all back to town.

As in Mossapoula there is a daily market traffic of women coming from Bayanga to sell "town" products and buy "forest" products. Bayanga farmers have also begun to plant fields south of Yandoumbé, in order to escape elephant depredations closer to Bayanga. They hire the BaAka to work in their fields, but increasingly compete with them for land, again renewing the conflicts that the BaAka sought to escape by moving away from Bayanga.

Yobé. Two small BaAka settlements near Yobé were established in 1994. Residents say they do not have time to work in the diamond fields or net hunt because they must protect their fields from elephants. The Yobé Bilos now provide food and lodging to people traveling to or from the diamond fields.

²⁷Yandoumbé and Lindjombo are the only BaAka villages that practiced group spear hunting during the research period.

Ecological Impacts of Human Activities

In the Bayanga region, hunting is an important subsistence and economic activity that links the ecosystem and the human system. Other economic activities affect the ecosystem by modifying habitat, but the effects of hunting on ecosystem components represented by game species are particularly direct (Heymans and LeJoly, 1981).

Human Activities and Habitat Change

Duikers are less abundant where there are large clearings or recently farmed areas, which do not provide suitable forage (Hart, 1985; Hart and Petrides, 1987; Von Richter et al., 1990). But fruit trees may be more abundant in late secondary forest, and duikers may use old secondary growth and primary forest equally (Fimbel, 1994). Research in Zaïre finds population densities for all duikers to be similar in primary and secondary forests, suggesting that the greater hunting pressure in secondary forests is offset by the more diverse and reliable food supply in these areas (Wilkie, 1987b; 1989; Wilkie and Finn, 1990).²⁸

Logging can have both positive and negative effects on wildlife populations. Logged forest may include fewer food resources if fruit trees are cut or destroyed, but offers

²⁸Struhsaker (n.d.) argues instead that hunted duiker populations in secondary forests in Zaïre are maintained by immigration of duikers from nearby unhunted primary forests.

thicker underbrush and more hiding places (Nummelin, 1990). However, blue duikers prefer forest with a relatively open understory, and are less abundant in logged forest (McCoy, 1995; Struhsaker, n.d.). Logging can alter the ranging behavior and diets of diurnal species by forcing them to range further, thereby increasing the risk of predation. Open canopy may also increase predation risks from eagles, while thickets may increase risks from leopards. Although strongly territorial animals may not move even if logging takes place in their home range, individuals in poorer condition are more vulnerable to disease if logging reduces or alters the availability of food resources (Johns, 1985; Wilson and Johns, 1982). At the same time, certain species (in particular elephants and gorillas) may benefit from logging, because they prefer the resulting secondary vegetation (Kingdon, 1982).

Implications of Hunting

In the Bayanga region, net hunting is a highly efficient method of capturing *C. monticola*. These duikers' reluctance to leave their home territories, and their tendency to hide rather than run from the approach of human hunters, make them particularly vulnerable to net hunting. The nets are placed in a closed circle, and beaters who shout and shake leaves attempt to drive any animals in the enclosed area from their hiding places and into the nets.

Larger duikers can sometimes jump over or break through the nets. *C. callipygus* is active by day in a territory that exceeds the area enclosed by the nets, therefore it often moves away from approaching hunters. The nocturnal *C. dorsalis* is reluctant to move even when it has been spotted, and can be speared in its sleeping place. The nocturnal *A. africanus* is often flushed from its shelter, although it may escape through the nets because hunters cannot seize it in their hands as they do the duikers. Young duikers that are still nursing usually remain hidden and are not located by hunters, but may die from starvation or predation if their mother is taken (Dubost, 1980).

Other hunting methods such as snares, shotguns, or crossbows capture duikers of any species and any age, except again young animals which remain hidden and immobile. Duikers and porcupines are easy to snare because they use regular paths (Crawford and Robinson, 1984; Wilson, 1987). Shotgun and crossbow hunters call duikers by imitating their distress cry, often bringing duikers to within several meters. Shotgun hunters also use flashlights and headlamps at night to locate and approach duikers and porcupines.

Humans are likely to be the most important predators on the Bayanga wildlife, and may keep actual population levels below unharvested levels (Crawford and Robinson, 1984; Eltringham, 1984). Populations may stabilize at a low level relative to unhunted populations if hunting is sustainable,

or may decline to extinction if hunting is excessive. Hunting may also alter age structures and sex ratios by removing adult individuals from the population. Game populations may respond to hunting pressure through changes in immigration and reproductive rates (Bodmer, 1995).

Changes in population structure

A number of studies suggest that more young duikers are found in a heavily hunted population because of dispersal from unexploited populations (Von Richter et al., 1990). Young animals must leave their parents' territory and establish their own, and can find unoccupied habitat where hunting has removed resident adults. For example, Table 3.12 reports data from a study of population structures for *C. monticola* between hunted and non-hunted areas in Gabon. These data suggest that hunting reduces the proportion of adults in the population (Chi square = 6.11, $p < 0.20$).

Table 3.12: Impacts of Hunting on *C. monticola*:
Age Classes in Hunted versus Unhunted Populations
(% of total population by age class)

	<u>M0</u>	<u>M1</u>	<u>M2</u>	<u>Subad</u>	<u>Adults</u>	<u>Repr</u>
Hunted	9	6	23	18	44	61
Unhunted	3	9	19	16	53	69

Notes: M0 = 0-4 months old, no molars visible.

M1 = 4-10 months old, 1st molar erupting, but not 2nd.

M2 = 10-20 months old, 1st and 2nd molars out, but not 3rd.

Subad = sub-adults, 20-28 months, complete dentition.

Adult = older than 28 months, tooth wear visible.

Repr = Total reproducing individuals including adults and subadults.

Source: Dubost, 1980.

Hunting has a heavy impact on reproductive age classes of duikers, especially gravid females. When territorial adults are removed by hunters, young animals are able to colonize the unoccupied areas rather than being forced to emigrate. As a result, young animals are relatively abundant in hunted populations. An archaeological study of BaAka net hunting in CAR finds a peak in duiker captures of the subadult class (Hudson, 1991). In Gabon, 77 percent of red duiker captures by gun and snare hunters are subadults (Lahm, 1993).²⁹

Likewise, a comparison of two sites in Zaïre, less than five kilometers and greater than 10 kilometers from agricultural settlements respectively, finds young duikers immigrating into heavily hunted areas. In this case, densities and age structure for *C. monticola* are similar at the two sites. However, *C. callipygus* and *C. dorsalis* populations are at a lower density and comprise more subadults where they are heavily hunted. Although immigration by young animals seeking territories of their own does occur, harvest rates apparently exceed immigration rates (Hart and Petrides, 1987; Koster and Hart, 1988).

Immigration from unhunted areas is only one explanation for relatively high proportions of young animals in hunted populations. Studies in southern Africa suggest that

²⁹However, the same study finds that only 26 percent of *C. monticola* captures are subadults, suggesting that hunting is more detrimental to populations of the larger duikers.

hunting stimulates population expansion of the grey duiker (*Sylvicapria grimmia*) through increased breeding rates and a larger proportion of juveniles reproducing (Child and Wilson, 1964; Wilson and Roth, 1967). Another possible explanation is that hunting induces behavior changes, as adult animals become more wary to avoid capture.

Changes in population density

The impacts of hunting vary among species and localities, according to local environmental conditions, wildlife population characteristics, and hunting patterns--for example, hunting technology and intensity. Hunting generally reduces wildlife densities to levels below those in unexploited areas (Robinson and Redford, 1991). In Zaïre, higher densities of *C. monticola*, *C. callipygus* and *C. dorsalis* occur in remote forest areas where hunting is infrequent (Hart, 1985). And in Gabon, Lahm (1993) finds population densities for *C. callipygus* declining by 90 percent (from 6.7/km² to 0.6/km²) between hunted and non-hunted areas, and *C. dorsalis* declining by 57 percent (from 5.8/km² to 2.5/km²). In the Bayanga region, the three duiker species and *A. africanus* densities decline by 25-50 percent between areas more than 5 kilometers from Mossapoula and areas within 5 kilometers of Mossapoula.

Sustainable harvest rates

Excessive hunting will result in the local extirpation of wildlife populations. But exploited populations may

stabilize if the harvest rate does not exceed the population's natural rate of increase. Based on biological data for the harvested species, Table 3.13 presents estimated annual sustainable harvest rates for the four game species in the Bayanga region (see Appendix 3 for the calculations). Because biological data are not available for the game species in the Bayanga region, I have calculated sustainable harvest rates according to theories based on other species, and according to a range of biological parameters--for example, age at first reproduction and gestations per year. Given the high degree of uncertainty with respect to the models and the parameters, wildlife managers should use the models cautiously and conservatively: overharvesting can be catastrophic for wildlife populations, and extinction is irreversible.

Table 3.13: Sustainable Harvest Rates
(percent of population per year)

	<u>Method 1</u>	<u>Method 2</u>	<u>Method 3</u>
<i>A. africanus</i>	11.2-29.2	9.9-39.5	15.0-67.5
<i>C. monticola</i>	2.3-6.0	8.6-34.4	7.5-12.8
<i>C. dorsalis</i>	1.6-6.0	5.5-21.8	7.5-12.8
<i>C. callipygus</i>	1.2-6.0	5.3-21.3	7.5-12.8

Sources: 1) Cole, 1954; Fa et al., 1995; Hennemann, 1983; Robinson and Redford, 1991; 1994b; Fa et al., 1995; 2) Caughley and Krebs, 1983; 3) Bodmer et al., 1994.

All three methods calculate the reproductive productivity of hunted populations, based on reproductive parameters or body size. Only a portion of this

productivity is available to human harvesters, because animals also die from natural causes such as predators, disease, and accidents. None of the methods take into account immigration from unhunted areas, which may increase population growth rates and raise sustainable harvest rates.

Continued resource use for human system/socioeconomic development and ecosystem/biodiversity conservation both require that wildlife resource exploitation be sustainable. The impacts of hunting on wildlife in the Bayanga region depend on the relationship between harvest rates for the game species, population densities, and reproductive productivity. Chapters 4 and 5 examine harvest rates by cable snare hunters and net hunters respectively. The density figures described above from transect surveys and net hunts are used with caution, together with comparative data from other central African sites. The sustainable harvest rates described above are also rough estimates, but are used in the absence of actual productivity figures.

Changes in the ecosystem

Reductions in game species populations through hunting also affects other components of the ecosystem (Redford, 1992; Robinson, 1993). Small mammals such as duikers and porcupines influence forest structure and vegetation diversity through seed predation and seed dispersal (Dirzo and Miranda, 1991; Dubost, 1980; 1984; Feer, 1989a; Gautier-Hion et al., 1985; Janzen, 1983; Lwanga, 1994). Through

competition for prey, hunting can regulate populations of natural predators such as leopards, golden cats, and mongooses (Jorgensen and Redford, 1993; Ray, in progress). Changes in forest structure, vegetation diversity, and predator-prey relations induce further changes in ecological relationships and biological diversity.

Relations Between the Ecosystem and the Human System: The Role of Hunting

This section explores the interactions between the ecosystem and the human systems in the Bayanga region by examining particular cases and issues related to hunting. Elephants compete directly with humans for land and resources, while each species benefits in some ways from the other's activities. Elephants are also an important resource from both conservation and development perspectives. The section examines in turn the implications for both systems of the following socioeconomic institutions: hunting legislation, bushmeat markets, and currency devaluation.

Elephants

Elephants play a key role in creating and maintaining the ecosystem of the Bayanga region. They are important architects of forest structure through their feeding behavior: they disperse seeds of fruits they consume, they damage trees by pulling down leaves and branches or

stripping bark, and they maintain forest gaps (Al  xandre, 1978; Lieberman and Lieberman, 1987; Kortlandt, 1984; Mabberley, 1983; Prins and Reitsma, 1989; Short, 1991; White, 1994b; Wing and Buss, 1970). Furthermore, elephants clear trails that benefit other wildlife and humans, and they maintain ba   clearings that attract wildlife, and in turn human hunters and tourists (Carroll, 1986a; 1986c). Reducing elephant populations by hunting therefore can result in changes in forest structure (Pullan, 1988).

In the past two decades, elephant populations may also have benefitted from the more abundant secondary vegetation resulting from logging and cultivation in the Bayanga region (Barnes et al., 1991; Prins and Reitsma, 1989; Short, 1983). Researchers have noted elsewhere that elephants prefer to forage in logged forest (Kasenene, 1984; Merz, 1986; Nummelin, 1990). However, selective logging generally assumes that the area will be logged a second time, after a regeneration period of 15-70 years. Because elephants feed on young trees of timber species and prevent or reduce regeneration, elephant conservation is not compatible with sustainable logging (Lwanga, 1994).

Elephants in the Bayanga region have been exploited for their ivory for over a century, most intensively under the concession system in the early 1900s. This exploitation continues today, with at least two elephants killed in the Dzanga-Sangha Reserve in 1994, despite the 1989

international ivory ban and a 1985 presidential ban on elephant hunting. Elephants were historically hunted for food as well, by the BaAka and others, and elephant meat is occasionally for sale in Bayanga today. However, anti-poaching efforts by the park project have greatly reduced elephant hunting since 1988.

Perhaps as a result of this protection, elephants have become serious crop raiders, as is frequently the case with protected areas in African forests (Dudley et al., 1992; Laurent, 1992; Naughton, in progress). Bayanga, Mossapoula and Gbabongo suffer the most from elephant depredations, sometimes within meters of houses. Elephants frequently visit fields within sight of Bayanga in the daytime, despite the crowds who try to chase them away.

Elephants trample and uproot manioc, although they eat little of the bitter variety which is most commonly planted. However, they destroyed the entire Bayanga maize crop in 1993. One farmer, on seeing the damage to his neighbors' maize, pulled up all his young and undamaged plants so that the elephants would not destroy the interplanted manioc when they came for his maize. No one planted maize in Bayanga in 1994. Some Bayanga residents have established fields near Koundapapaye and south of Yandoumbé, in both cases competing for land with BaAka residents who had moved there first in order to distance themselves from conflicts with Bilos. At times Bayanga residents buy manioc from the BaAka in

Mossapoula or Yandoumbé--a reversal of traditional roles. However, crop damage in Mossapoula has discouraged some BaAka from farming, and may prolong their dependence on day labor in Bayanga.

Elephants are also the source of tensions between the project and local residents. Elephants are seen as the project's "children", whom the project does nothing to discipline when they destroy people's crops. The project has unsuccessfully tried several crop protection measures: in trying to kill one crop raider, 12 shots were fired but the animal escaped; efforts to shoot crop raiders with salt was discontinued because the guards never were close enough to shoot;³⁰ shooting blanks was also discontinued because the elephants soon learned they were not in physical danger and ignored the shots. A solar-powered electric fence is now being tested around a few fields in Bayanga.

Most local people believe that killing elephants occasionally as Slovenia-Bois did in the 1970s will keep them away from villages.³¹ However, for public relations reasons WWF cannot support shooting elephants, nor is such action compatible with the park, whose principal tourist attraction is elephants. But their damage to crops is an important and very visible cost borne by local residents,

³⁰Shooting with salt is intended to hurt and frighten the animal without causing permanent injury.

³¹The elephants were killed to provide meat to employees.

generating strongly negative attitudes towards conservation efforts.

Elephants also conflict with snare hunters, as encounters are frequent. Usually the elephants flee. But in 1994, a snare hunter was killed by an elephant near Salo. My informants and I were charged on two occasions when we suddenly came upon a mother elephant and her infant. Elephants also frequently spring and trample snares: Mossapoula hunters during one period said they had removed all their snares from the forest because elephants were springing too many. Finally, one of the snare hunting camps that I visited regularly was destroyed four times over the course of one year by elephants.

Hunting Legislation

All wildlife in CAR belongs to the state. At independence in 1960 all of southern and western CAR (including the Bayanga region) was declared a "Zone de Chasse Banale" for subsistence hunting (Kundaeli, 1984). However, even in these areas hunting is regulated by a national wildlife code. The wildlife code includes three lists of species (Appendix 4): protected, partially protected, and unprotected (République Centrafricaine, 1984). The partially protected species may be hunted only by persons possessing a valid hunting license, only adult

male animals may be killed, and a head tax is levied for each animal killed.

A hunting license includes several fees: one-time fees of a "taxe spéciale sur arme" or weapon tax (30,000 CFA), and a "carnet PPA" or firearm license folder (5,000 CFA); as well as annual fees of a "permis de port d'arme" or permit to bear a firearm (5,000 CFA), a "permis petite chasse" or small-game license (5,000 CFA), and a "carnet permis de chasse" or hunting license folder (5,000 CFA). Hunting for bigger game requires a "permis moyenne chasse" or medium-game license (20,000 CFA per year). Most gun owners hire hunters, but if a second hunter will use the firearm, that person must have his own hunting license (15,000 or 30,000 CFA) and a "permis complémentaire" or complementary license for the firearm (5,000 or 10,000 CFA), both of which are renewable each year. In addition to licenses, a "taxe d'abattage" or head tax is payable for all mammals larger than rodents (Table 3.14). In several cases, the head tax equals or exceeds the Bayanga market value of the animal: blue duiker, yellow-backed duiker, bongo, sitatunga, and all monkeys.

Table 3.14: Head Tax Levied on Game Species
(CFA francs)

<u>Species</u>	<u>CFA</u>
Bongo	100,000
Sitatunga	100,000
Buffalo	20,000
Giant forest hog	15,000
Yellow-backed duiker	10,000
Bush pig	8,000
Other duikers	2,000
Monkeys	2,000

Note: These are the taxes payable by all CAR residents. The tax for non-residents is five times the resident rate for each species.

Cable snares, widely used since Europeans introduced wire cable to central Africa in the 1950s, are everywhere illegal (Lahm, 1993; Rodgers et al., 1991). Subsistence hunting may only target unprotected species, and may only use "traditional" technologies such as crossbows, nets and spears.³² Not all of the technologies described as "traditional" are indigenous to the peoples now using them. Crossbows were introduced to Africa by the Portuguese in the 16th century, (Bahuchet, 1989; Bahuchet and Guillaume, 1982; Koch, 1968; Kretsinger, 1993; Motte, 1982). Hunting nets may have been introduced in southwestern CAR by the French in the 1920s in order to increase exports of duiker skins.³³ The demand for meat also increased from loggers,

³²However, the use of poison is officially forbidden, even though crossbows are virtually useless if poison is not applied to the darts.

³³Other ethnic groups in CAR hunted with nets well into the colonial period, but not in the Bayanga region.

diamond miners, coffee plantation workers and rubber harvesters. The BaAka therefore became duiker hunters and adopted nets under pressure from colonial companies and from neighbors to increase duiker skin and meat production (Bahuchet, 1985b; Bahuchet and Guillaume, 1979; Hewlett, 1991).

Few of these wildlife code regulations are enforced anywhere in the country, except where there is a park with game guards. Thus the wildlife laws have only been enforced in the Bayanga region since efforts to create the Dzanga-Ndoki National Park and Dzanga-Sangha Special Reserve began in 1988. Even in Bayanga, enforcement focuses mainly on firearms and especially on elephant guns, and to a lesser degree on cable snares. The project makes no attempt to levy head taxes on animals killed by local hunters, nor to require hunting licenses of crossbow, net and snare hunters.

To date, high costs have limited the use of firearms in hunting: before devaluation shotguns cost at least 100,000 CFA, and ammunition 500-2,500 CFA per round. Licenses to legally own and operate a firearm are also expensive (see above), and with the park now confiscating unlicensed firearms, only government authorities and a few wealthy individuals own guns in Bayanga. In August 1994 there were eight legally registered firearms in Bayanga.

Bushmeat Markets

Local peoples have exploited duikers and porcupines in the Bayanga region for generations, mainly for meat but also for duiker skins in the past. Currently wildlife is exploited for local markets and for export. Bushmeat is sold whole or by the piece, fresh or dried. *C. monticola* and monkeys are cut in half lengthwise, after the head and internal organs are removed. Medium-sized duikers are quartered, while larger animals are divided into six or more pieces. Pieces weigh between one and three kilograms when fresh, and as little as half as much when dried.

Despite efforts to prohibit the export of bushmeat from Bayanga to Nola and Berberati, a project survey by Godia Guembi Jules and Maka Sylvestre from May to November 1994 found that roughly 1.4 sacks, or 26.9 pieces (range 0-340, SD $\pm$ 37.78), of bushmeat leave Bayanga each day by public bus.³⁴ Because bushmeat exports are illegal, the survey undoubtedly underestimates total exports. Some bushmeat is transported by river, some is purchased by merchants in settlements north of Bayanga such as Gbabongo. However, without the park project's surveillance, bushmeat exports would undoubtedly be much higher, as prices for bushmeat in urban markets are two or more times Bayanga prices.

³⁴Daily exports ranged from 0 to 340 pieces, with a standard deviation of 37.78.

Given the population concentrated in Bayanga, and the income from the logging company, the project, and informal employment, the local market for bushmeat is also important. However, from March to December 1994 my assistant Bopokina Elbert found bushmeat for sale in the public market (open daily from 8-12 a.m.) only once every four days. Most bushmeat is sold instead at the hunter's house. Two other surveys from May to December 1994 measured bushmeat availability in Bayanga. First, I hired Ndombe Blaise to record information on daily bushmeat production by hunters in his neighborhood: how many animals for sale, what species, and whether they hunted with snares or guns. Second, the same two project employees who surveyed bushmeat exports also recorded the number of locations with bushmeat for sale each day, and the quantity of meat for sale at each location. The latter survey identified the meat only according to three categories: monkeys, pigs or antelope. Neither survey is comprehensive, as it is difficult for surveyors to locate every informal market when more than 60 individuals hunt. Furthermore, protected animals are not sold openly, and many small animals are eaten by the hunter's family rather than sold. Therefore the total production of bushmeat for Bayanga is even higher.

The two informal market surveys both find bushmeat for sale in Bayanga on 95 percent of observation days. On average, at least three locations have bushmeat for sale

each day. Just over half the bushmeat (52 percent) comes from snare hunters, the rest from gun hunters. Virtually all the meat is from Bayanga hunters, and the BaAka no longer are the principal meat suppliers to other ethnic groups: the two surveys respectively found 18.1 (range 0.53, SD $\pm$ 10.65) and 33.9 (range 0-185, SD $\pm$ 22.12) pieces of bushmeat available in Bayanga informal markets each day. The supply from Mossapoula averages only 2.4 pieces per day (range 0-13, SD $\pm$ 3.14), and a similar quantity may come from the other neighboring BaAka village of Yandoumbé.³⁵ Duikers dominate the bushmeat markets (Table 3.15). Porcupines are absent because local residents say their meat has the best flavor, and prefer to eat porcupines rather than sell them.

By imposing restrictions on the supply and trade in bushmeat--limiting where and how hunting may take place, and prohibiting exports--the project increases overall public resentment towards conservation efforts. People say that the project does not allow them to feed themselves (Kretsinger, 1993). This resentment exploded into a major riot in November, 1993 when a cable snare poacher was injured while being arrested by game guards. One project vehicle, several dugout canoes, and several guard houses were damaged over the course of three days.

³⁵Communal net hunting produces relatively little surplus for sale, because yields per hunter are very low relative to yields per snare hunter (see Chapter 6).

Table 3.15: Observed Bushmeat Sales by Species
(pieces of meat and whole animals)

	<u>Survey 1</u>				<u>Survey 2</u>	
	<u>Pieces</u>	<u>%</u>	<u>Animals</u>	<u>%</u>	<u>Pieces</u>	<u>%</u>
All antelope					4,647	80.9
Red duikers	1,897	54.6	475	41.0		
<i>C. monticola</i>	778	22.4	389	33.6		
Monkeys	432	12.4	216	18.6	647	11.3
<i>P. porcus</i>	155	4.5	26	2.2	449	7.8
Other	211	6.1	53	4.6		
Total	3,473	100.0	1,159	100.0	5,743	100.0

Notes: Survey 1 by Ndombe Blaise, May-December 1994; Survey 2 by Godia Guembi Jules and Maka Sylvestre, May-November 1994. Both were neighborhood surveys of informal markets.

Several categories are aggregated because many animals, once they are cut in pieces and smoked, are difficult to identify:

"Monkeys" include *Cercocebus* spp., *Cercopithecus* spp., *Colobus* sp. and *Procolobus* sp.

"Red duikers" include *C. callipygus*, *C. dorsalis*, *C. leucogaster*, and *C. nigrifrons*.

"All antelope" include all duikers as well as occasional bongo (*T. euryceros*) or sitatunga (*T. spekei*).

While the project has restricted bushmeat production and trade, logging activities have facilitated both by providing and maintaining transportation systems, by increasing access to forest areas, and by acquainting employees with forest areas which they can exploit through hunting. Diamond mining, like logging, induces immigration to the Bayanga area, and increases the demand for bushmeat. At least one BaAka hunting camp was established in 1994 near the Yobé diamond fields in order to supply bushmeat to the miners.

One alternative to bushmeat for local consumption is beef. However, cattle are raised only in the savanna areas

north of Monassao. When Bayanga is prospering, a butcher periodically drives a herd of several cattle down to Bayanga and butchers an animal every other day, returning north to collect more cattle when all his meat is sold. The beef supply in Bayanga is therefore intermittent, with beef available in the public market on only 59 percent of market days. But demand for beef is high, with an entire cow (weighing roughly 200 kilograms) selling within two days, despite higher prices: 1,000-1,500 CFA/kg for beef, versus 900-1,000 CFA for a Peters duiker quarter that weighs over two kilograms when it is fresh. Because beef is only supplied when economic conditions are good, Bayanga residents have fewer alternatives, and are therefore more dependent on bushmeat, in periods when major employers like the logging company are not operating.

Currency Devaluation

In January 1994, the currency used by CAR and 11 other francophone African countries was devalued 100 percent. The CFA franc has been pegged since 1948 to the French franc at 1 FF = 50 CFA francs (\$1 ≈ 290 CFA). Overnight the new pegged rate became 1 FF = 100 CFA (\$1 ≈ 590 CFA). The move was pushed by the International Monetary Fund and World Bank as a key measure to reduce imports and to boost exports such as coffee, diamonds, and timber by making their prices of these products more competitive on world markets. However,

subsequent increases in the price of imported fuel imported have driven price increases in all other products, including those necessities produced in CAR such as sugar and soap. Because local people need to obtain cash to purchase these items, they are also raising prices of commodities they produce: manioc and bushmeat. Economic difficulty may put even greater direct pressure on wildlife resources. At the same time, greater export production from logging, diamond mining and coffee plantations indirectly harms wildlife by reducing habitat. If resources like timber and diamonds are found in forests, people will enter forests to collect them, and will hunt wildlife to feed themselves while they are there.

Conclusion

The Bayanga region has a long history of subsistence and commercial forest resource extraction, with periodic economic booms and busts as various products became valuable and then declined. As a result of successive immigration waves, the local ethnic mix is diverse. Today hunting continues, as a subsistence and commercial activity, representing one component in a mixed economic strategy for most residents. Different villages follow different economic strategies, though all hunt to some degree. A diverse set of international, national, and local actors also influence wildlife exploitation with various

objectives: conservation, development, subsistence, or wealth accumulation. The result is that the importance of hunting varies over time, and among settlements and ethnic groups according to their human and natural environments.

The following chapters examine two cases in detail, the Bilo cable snare hunters of Bayanga and the BaAka net hunters of Mossapoula. The analysis focuses in particular on the effects of each hunting method on wildlife, the economic importance of wildlife exploitation for each group of hunters, and the potential for sustainable wildlife utilization. Sustainable exploitation is important both from a biodiversity conservation perspective and from a socioeconomic development perspective. This chapter has estimated population densities as well as predicted sustainable harvest rates for the primary game species in the Bayanga region. The following chapters compare these figures with actual hunting offtake levels.

CHAPTER 4 CABLE SNARE HUNTING IN BAYANGA

Cables snares are probably the most widely used hunting method in African forests today. They have replaced a diverse array of traditional snaring and trapping techniques: pit traps, gravity traps, net traps, and many types of noose snares. Traditional snares and traps generally targeted specific prey species. Cables snares are an easy and effective hunting technique that kill a wide range of prey species. Noose snares are much easier to construct than pit or gravity snares, and cable is stronger and more durable than the natural fibers traditionally used in noose snares.¹ Relative to traditional methods, cable therefore allows hunters to use a simpler snare method for capturing larger animals. Cable for snares is much more affordable and accessible to local hunters than are firearms. Hunters report that their grandfathers knew how to make snares with vines and natural fibers, but that this knowledge has been forgotten.

Yet very little research addresses cable snare hunting. Anecdotal information suggests that snare hunting is

¹The cable for making snares comes from cables used in logging operations. Nylon, another "modern" material, is also used by children to set snares for birds and rodents.

decimating forest wildlife: in addition to the numerous harvested animals that are eaten by hunters or are sold in local markets, many others escape injured, or are lost to scavengers and decomposition. After introducing the methodology employed, this chapter describes snare hunting as practiced by Bayanga residents, and addresses in turn the two research questions: 1) what are the impacts of snare hunting on wildlife? and 2) what is the economic importance of snare hunting for Bayanga residents? Of particular interest are the sustainability of snare harvests, and the relationships between snare hunting and other economic activities. The chapter concludes with comparative data from other research on snare hunting and bushmeat markets in Central African forests.

Cable snares are the dominant hunting technique used by Bayanga residents. However, they are also illegal, and the Dzanga-Sangha project has enforced the national wildlife code in the Bayanga area since 1988. Guards patrol the Dzanga-Ndoki Park and the Dzanga-Sangha Special Reserve, confiscating snares and destroying snare hunter camps. If they catch a snare hunter, they report him to the local authorities, and deposit a citation with the court in Nola. To date, no cases have been tried, and no further punishments administered. Therefore the hunter loses at most his snares and possibly some meat. In many cases the hunter obtains a new supply of cables and is back snare

hunting within weeks. In practice, anti-poaching measures are not an effective deterrent to cable snare hunting in the Bayanga region.

Methodology

The illegal nature of snare hunting complicated and restricted my research efforts. I negotiated with the project for permission to accompany snare hunters. Initially some of the project authorities demanded that I study snare hunting by accompanying guard missions, and asked that I report all informants. In turn, some hunters were afraid I would turn them in to the project. Others said I would write a book and become rich from my research, therefore I should reward them financially for their help. However, the project did not want me to pay informants because people might say I, and therefore the project which allowed me to study snare hunting, was encouraging cable snare hunting. At the same time I wanted to observe people's practices without influencing their hunting.

I was able to find individuals willing to cooperate primarily because my assistant Ngbongo Yves explained our objectives to friends and persuaded them to help. However, my first informant found a job in Salo and moved away; another was caught by guards and lost many of his snares. Another group of informants, upon our return to Bayanga, became abusive in demanding money. The November 1993 riots

further exemplified the risks of seeking new informants. In weighing the trade-offs between few trips with many informants, or many trips with few informants, I chose the latter. Therefore, a large proportion of my data are from one informant who hunted continuously from February to December, 1994. From February to May he hunted alone. In May he was joined by two other hunters, one who stayed only three weeks, while the other stayed six weeks. In September he was again joined by another hunter. I made several additional one-time trips with other hunters working alone and in groups. In total, I accompanied 17 Bayanga snare hunters to four hunting camps (Figure 4.1), for 96 person/observation days (Appendix 5). Some snares were within one kilometer of Bayanga, while the most distant camp was 25 kilometers from town.

I relied principally on participant observation of hunting activities. I counted total snares set, noted how frequently snares were checked, how frequently they were relocated, and whether captured animals were eaten or sold. In addition, I recorded snares that sprung accidentally and instances where animals escaped by breaking the cable, identifying the species when possible. For all captures, I recorded the following biological information: species, sex, age, weight, measurements, and reproductive state. I did not measure animals that were excessively decomposed or

scavenged, but recorded them as wastage. Finally, I interviewed the hunters.

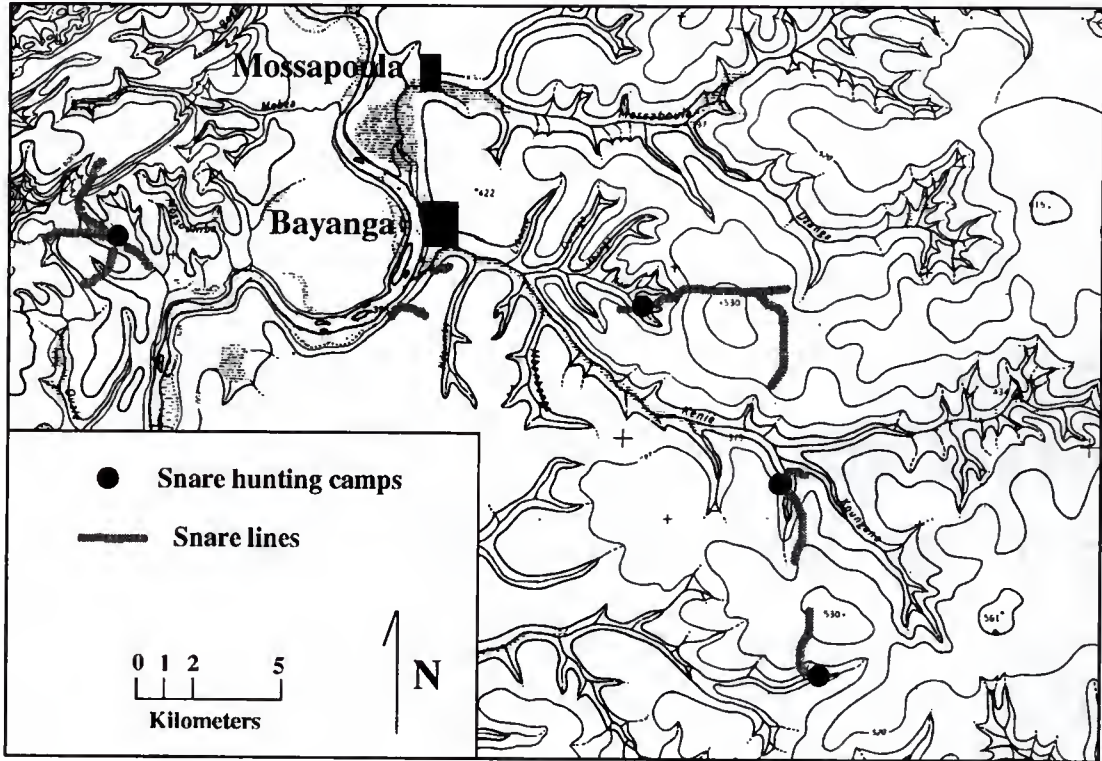


Figure 4.1: Bayanga Snare Hunting Camps and Snare Lines

Description

Women occasionally set a few cable snares at the edge of their fields, but snare hunting is overwhelmingly a male occupation. Cable snares are popular because they are cheap and effective: hunters purchase cable for 300 CFA per yard, and from each yard can make four or more two-strand snares, or over 10 single-strand snares. The capital investment in an average snare line of 60-100 snares is 5,000-7,500 CFA, and cables can last over two years. The total cable

investment for a snare line can be recouped with the sale of only two large duikers (worth 3,800 CFA apiece) or five small duikers (1,500 CFA apiece). In comparison, a shotgun can cost 100,000 CFA or more, licenses to own and shoot the gun another 15,000-30,000 CFA per year, and cartridges 500-2,500 CFA apiece (see chapter 3). This section examines the types of snares employed by Bayanga hunters, describing as well their activities and hunting range.

Snare Types

The principal snare type is the foot snare: the hunter digs a small hole on an animal trail and covers it with a platform of bark or small sticks which acts as a trigger mechanism. A cable noose encircles the edge of the hole and is attached to a bent-over pole. When an animal steps on the pressure pad, the pole springs up and tightens the noose around the animal's leg. Sometimes sticks are laid on the ground at the edges of the hole in order to encourage animals to step directly and more firmly on the pressure pad. Also, small sticks may be stuck upright on either side of the trail to guide animals over the snare.

Foot snares will occasionally catch bush pigs by the snout, or elephants by the trunk. Small animals like the brush-tailed porcupine (*Atherurus africanus*) and the blue duiker (*Cephalophus monticola*) may be lifted off the ground, but the larger Peters duiker (*C. callipygus*) and bay duiker

(*C. dorsalis*) are merely held by the pole planted in the ground. Death is gruesome as the animal fights to free itself, often breaking the captured limb, and dying slowly of shock, blood loss, exhaustion and starvation. Porcupines and mongooses will occasionally chew off a foot and escape. My informants in general used 2-strand cables for foot snares. But large animals such as bongo or bush pigs can break the cable and escape, unless 3- or 4-strand cables are used. Large animals that break the cable often suffer severe cuts or broken limbs as they struggle to escape, and the noose usually remains tightly attached to their leg. Cable snare injuries may cause gangrene, resulting in the loss of a limb or death.

The other type of snare used by informants is a neck snare: a small frame holds an open noose vertical and above the ground. When an animal tries to pass through the frame, it sticks its head through the noose and presses down on a trigger stick that releases the spring pole to which the cable is attached. Death is quick with a neck noose, except when animals spring the snare by stepping on the trigger stick, and are caught by the leg rather than the neck. Neck snares are set at the entrance of giant rat (*Cricetomys emini*) holes and along porcupine trails. These snares therefore target particular species, but comprise less than 10 percent of a hunter's snares. Most neck snares are single-strand cables.

In a variation of the neck snare method, a hunter makes a fence with branches and leaves, in order to direct animals to certain paths through the fence where as many as 30 snares, 2-5 meters apart, are set. These fence snares, called "alangasa" in Gbaya, are particularly effective on small animals such as rats, but can also capture blue duikers, mongooses, or pangolins, as well as birds and snakes. Neck snares capture animals that are eaten in camp or at home, not sold.

Snares are selective only with respect to prey size. In practice, elephants are safe from foot snares because their feet are larger than the noose circumference.² Very small animals are also immune because they are too light to release the snare trigger. Animals larger than a blue duiker are generally safe from fence and neck snares, which use small nooses and guard small trails. But with respect to species, age, and sex, snares are a non-selective hunting technique, sprung by any animal using a given trail.

Snare Hunting Practices

Snare hunters, alone or with one or two companions, set a string of 55-100 snares apiece (mean 74, SD $\pm$ 13.25, N = 10 complete snare lines) along a 1-3 kilometer course. A hunter can set 20 or 30 snares in a single day, including

²However, one informant reported finding the severed end of an elephant's trunk by a destroyed snare--elephants can be injured if their trunk springs the snare.

the time it takes to identify likely animal trails, find poles and bark, and dig the holes. Most trails are created by elephants, but are used by all other animals, so a particular species cannot be targeted.³ The exceptions are small trails used by *A. africanus*. Most snares are set in mixed forest, or at the mixed/monodominant forest edge, where animal trails are more visible. In monodominant forest animals are not restricted in their movements by undergrowth, and trails are less important.

Snares remain in place for a month or longer. Every week a hunter moves individual snares, when he judges that animals no longer use that trail, as he loses a few to escaped animals, or others are damaged in capturing an animal, and as he repairs old snares or obtains new cable. Every 1-3 months he moves a major section (one-third or one-half) of his snares, seeking a more productive area--further from camp in the same general direction, or shifting them in another direction.

Some hunters set snares within two hours' walk of Bayanga, and check them on day trips. Generally these part-time hunters can only visit their snares on afternoons or weekends because of other economic activities, such as logging company or project employment. Full-time hunters build camps in the forest where they stay for a night, a

³Informants reported single snares at a single location capturing as many as six animals, of five different species.

week, or a month--depending on the yields and the distance from Bayanga--in order to monitor their snares and smoke the meat for transportation back to Bayanga. They eat manioc, which they must carry from Bayanga to their hunting camp, with any small animals they catch: for example, rats, porcupines, and even blue duikers. Portions of large animals that are not sold, such as the head and internal organs, are eaten as well. Most hunters also eat fish which they catch by day or by night in the streams near the camp, saving the snared meat to sell in town. But if they run out of manioc they return to town.

A hunter will spend 2-8 hours checking his snares, though only about one hour is spent walking the line. The additional time is spent walking to or from camp or town, and resetting sprung snares or setting new ones. If he only checks his snares every other day, he spends alternate days in forest camps resting, fishing, making backpacks, etc. Travel time from Bayanga to the camps I visited ranged from three to eight hours. One trip was three hours by canoe, then two hours' walk. Other camps were reported to be more than one day's walk from Bayanga. Usually snare hunters travel to camps with other hunters, but occasionally a hunter will be accompanied by his wife, who cooks, fishes, gathers, and helps to check snares. Children may accompany their mother, or remain with relatives in Bayanga.

Animals caught in snares are carried back to the camp and butchered, except for animals too large to carry whole, like bush pigs, which are butchered on the spot. The meat is immediately placed on racks over hot fires, and covered with leaves. It must be turned a couple times during the first day, until it is dry, after which it will keep for as long as a month if it remains over a fire. Animals that have been dead for a couple days and have begun decomposing are rarely discarded entirely, though this meat is more likely to be eaten than sold.

When returning to Bayanga, the meat is carried in rattan backpacks. The hunters I accompanied come into Bayanga during the day by foot trail or by canoe. Those hunting west of the Sangha river believe that their hunting is legal--they say mistakenly that they are outside the Reserve or even in Cameroon. However, they now hunt across the Sangha, where the guards do not patrol, because of previous harassment from guards east of the Sangha. Those hunting east of Bayanga in the Reserve and the Park know that their activities are illegal, but are not deterred by the risk of being caught and losing their snares. During 96 observation days over 22 weeks, I did not encounter any guards. Only one camp of the four I visited was discovered

by guards during the research period, several weeks after my visit.⁴

Hunters check their snares as often as daily while they are in their forest camp, but they may spend a week or more in Bayanga without visiting their snares. Of 91 days when hunters checked snares, the interval since their previous visit varied from 1-10 days, averaging 2.6 days (standard deviation 1.79). Little meat is wasted when the snares are checked every day or two; what is lost is taken by carnivores. Most of the losses to decomposition and scavengers occur when the snares remain unchecked for three days or more. The only exceptions in 33.5 unrecovered animals were a blue duiker taken by a leopard, and two guinea fowl and a squirrel eaten by mongooses. The relationship between losses and length of the interval between hunter visits is statistically significant: Spearman's rank correlation coefficient $r_s = 0.569$, $p < 0.01$. In some areas over a day's walk from Bayanga, where hunting is very successful, snare hunters returning to town cover the pressure pads with large pieces of bark so that animals will not be caught during their absence.

A camp is used for six months or more: one informant has used the same camp for over one year, though his snare line now begins two hours away from his camp. He would

⁴In that instance the guards caught another pair of hunters, and ordered them to reveal their campsite--these hunters instead led them to my informants' camp.

prefer to move the camp to a site closer to the snares, and will do so if he finds a suitable location near water.

Although all camps are near streams, the abundance of water in the region means that few if any areas are outside the range of snare hunters. Camps are usually shared by 2-10 hunters.⁵ Snare lines are shared by 1-3 hunters, therefore larger camps service several separate snare lines.

Snare hunting is practiced throughout the year, regardless of the season. Numerous reasons are given, even by the same hunters during a single week, for poor success rates from snare hunting: bad luck, God's will, they did not sacrifice to the forest spirits, the area was overhunted, too much rain, too dry weather, arguments in camp, or one hunter's wife's pregnancy. People do say that animals were more abundant in the same areas in the past, or that animals are more abundant further away from Bayanga. They speak of areas to the southeast of Bayanga, near the Congo border, where people have caught 3 bush pigs or 16 blue duikers in a single day. But they do not believe that snare hunting can exterminate local wildlife. They blame wildlife depletion near urban areas like Bangui, Berberati, Mbaïki, and Nola on the abundance of firearms.

⁵Informants tell of one unusually large camp that housed 17 hunters. Market women from Bayanga visited the camp to sell alcohol and manioc, and to purchase meat.

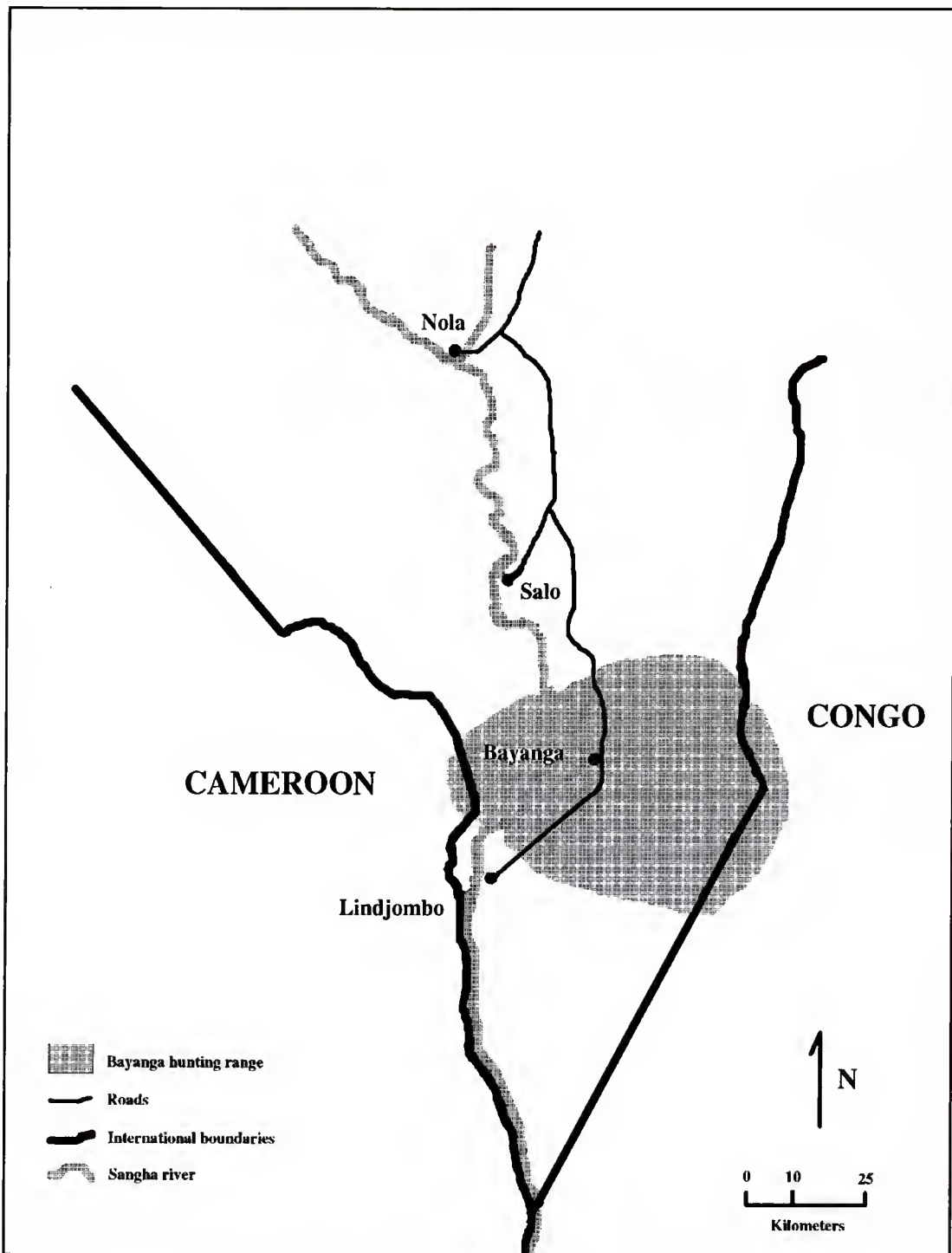


Figure 4.2: Bayanga Snare Hunting Range

Snare Hunting Range

Snare hunters from Bayanga range widely (Figure 4.2): north to the Yobé diamond fields, east across the Congo border, south beyond Lindjombo, and west across the Sangha river to the Cameroon border. This range of roughly 1,000 square kilometers includes the entire hunting ranges for Mossapoula and Yandoumbé, and overlaps on its edges with hunters from Salo to the northwest, Gbabongo and the Yobé diamond fields to the northeast, and Lindjombo to the southeast.

Assuming that 60 Bayanga snare hunters maintain 70 snares apiece, there are 4,200 snares in the Bayanga hunting range, or 4.2 snares per square kilometer. Given 21 Mossapoula hunters with 19 snares apiece, there are an additional 3.6 per square kilometer in the 110 square kilometer Mossapoula hunting range, or a total of 7.8 snares per square kilometer.

Impacts of Cable Snare Hunting on Wildlife

This section examines the effects of cable snare hunting on wildlife in the Bayanga region with respect to the species distribution, age structure, sex ratios and wastage of captured animals. Additional data describe animals that escape injured and assess the sustainability of cable snare oftakes in the region.

Cable snares capture virtually every species of mammal except elephant and perhaps hippopotamus, as well as several species of birds and reptiles (see Appendix 4). Few if any mammals are completely arboreal. Even monkeys and tree hyrax are captured from time to time in snares set on the ground. Special snares can also be set in trees for arboreal animals: several hunters in Bayanga are apparently adept at setting cable snares in trees to capture monkeys. Birds such as guinea fowl and francolins, as well as eagles, are also captured in foot and neck snares on the ground. Foot snares, the most commonly used technique, cannot selectively target particular species, and are set along trails that many species use.

Captures

I collected data with Bayanga snare hunters for a total of 18,870 snare nights.⁶ The snare captures include 21 species: 18 mammals, two birds, and a reptile (Table 4.1). All snares--foot, neck and fence--were set on the ground.

⁶Snare nights are defined as the number of snares times the number of nights they were set, excluding snares that sprung accidentally.

Table 4.1: Observed Cable Snare Captures
(number of animals and kilograms by species,
foot, neck and fence snares)

<u>Species</u>	<u>Number</u>	<u>Percent</u>	<u>Kgs</u>	<u>Percent</u>
<i>Cephalophus monticola</i> *	38	31	116.5	16
<i>Cephalophus callipygus</i> *	36	29	395.0	56
<i>Atherurus africanus</i>	11	9	19.5	3
<i>Cricetomys emini</i>	8	7	6.8	1
<i>Cephalophus dorsalis</i> *	7	6	71.0	10
<i>Agelastes niger</i>	3	2	0.5	..
<i>Potamochoerus porcus</i> *	2	2	70.0	10
<i>Nandinia binotata</i>	2	2	4.8	1
<i>Bdeogale nigripes</i> *	2	2	3.5	1
<i>Francolinus</i> sp.	2	2	0.3	..
<i>Funisciurus pyrrhopus</i>	2	2	0.1	..
Rat (unidentified)	2	2	--	--
<i>Cephalophus nigrifrons</i> **	1	1	13.5	2
<i>Cercocebus galeritus</i>	1	1	4.0	1
Snake (unidentified)	1	1	2.8	..
<i>Manis tricuspis</i> *	1	1	1.5	..
<i>Protoxerus stangeri</i>	1	1	0.5	..
<i>Atilax paludinosus</i> *	1	1	--	--
<i>Cephalophus leucogaster</i> *	1	1	--	--
Monkey (unidentified)	1	1	--	--
Squirrel (unidentified)	1	1	--	--
Total	124	100	710.1	100

Notes: *Partially protected species. **Fully protected species. Kgs are for recovered animals only, and underestimate total biomass harvested. (--) indicates unrecovered animals. (..) indicates less than 1 percent.

N = 29 hunter-weeks and 18,870 snare nights.

The most abundant species captured is *C. monticola*, representing 31 percent. However, *C. callipygus* is captured in virtually equal numbers, 29 percent, despite its lower population density: 0.9-3.7 versus 10.5-66.9 per square kilometer for *C. monticola*. Being a much lighter animal, *C. monticola* is less vulnerable to foot snares which spring from the pressure of an animal's weight. A statistical comparison of captures with estimated population densities

for the four primary game species reveals that snares are selective, capturing more *C. callipygus* and fewer *C. monticola* than expected according to their relative abundance: G-test, $G = 17.53$, $p < 0.01$. Including all snare encounters, captures as well as injured escapes, the same selectivity patterns hold: $G = 28.16$, $p < 0.01$.

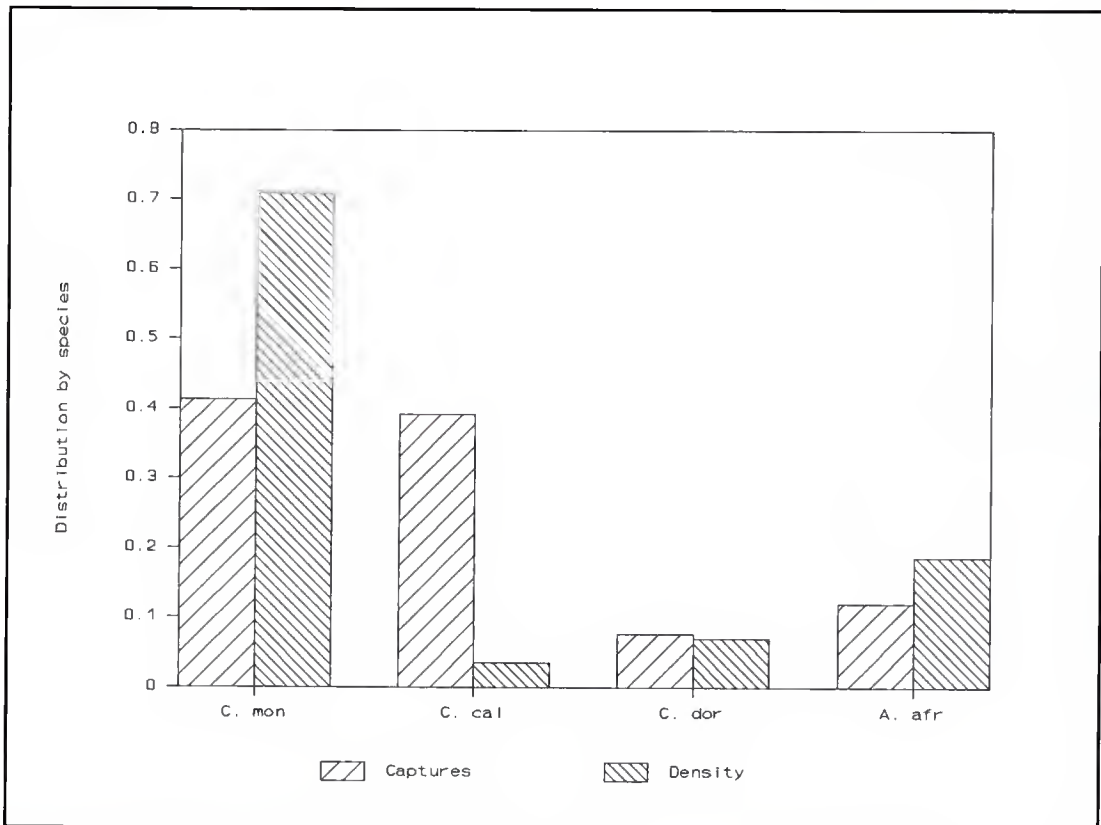


Figure 4.3: Relative Distribution of Snare Captures and Abundance for Primary Game Species

Notes: Capture data are from Table 4.1, density data are minimum net hunt encounter data D2 from Table 3.5, for areas 10-15 kilometers from Mossapoula.

G-test: $G = 17.53$, $p < 0.01$.

Figure 4.3 shows the observed distribution of catches by species compared with the relative abundance of the four primary game species in areas 10-15 kilometers from Mossapoula, where most snare hunters that I accompanied hunted.

C. callipygus is the primary catch of foot snares, providing 56 percent of returns by weight (versus 16 percent for *C. monticola*): hunters speak of their returns in terms of numbers of "ngendi" (*C. callipygus*). Smaller animals, including *C. monticola*, are more often eaten in the forest or by the hunter's family in Bayanga, whereas *C. callipygus* quarters are the primary commercial unit. *A. africanus* and *Cricetomys emini* are also caught relatively frequently, nine percent and seven percent of captures respectively, though more often with neck snares (particularly *C. emini*). These small animals comprise only three percent and one percent respectively of returns by weight, and are eaten, not sold. *C. dorsalis* is the next most common prey species, representing six percent of all captures (ten percent by weight).

The remaining 24 captures include 16 species. Though only two bush pigs (*Potamochoerus porcus*) were captured, these were the largest captures and comprised 10 percent of total returns by weight. Additional species may be caught in greater numbers by people hunting in other forest types: riverine forest and marshes for *H. aquaticus*, *T. spekei*, *C.*

nigrifrons, and crocodiles. Different types of snares also capture different species: 3-4 strand cable foot snares for large game like *P. porcus*, *T. euryceros*, or *S. caffer*; and snares set in trees for monkeys.

Four hunters reported captures during weeks that I did not accompany them, although they only reported recovered marketable animals (Table 4.2). Reported captures include two species not recorded in Table 4.1: the yellow-backed duiker *C. sylvicultor* and the golden cat *Felis aurata*.

Table 4.2: Reported Cable Snare Captures
(number of animals by species)

<u>Species</u>	<u>Number</u>	<u>Percent</u>
<i>Cephalophus callipygus</i> *	29	37.7
<i>Cephalophus monticola</i> *	27	35.1
<i>Cephalophus dorsalis</i> *	9	11.7
<i>Atherurus africanus</i>	5	6.5
<i>Potamochoerus porcus</i> *	5	6.5
<i>Cephalophus sylvicultor</i> *	1	1.3
<i>Felis aurata</i> *	1	1.3
Pangolin*	1	1.3
All species	78	100.0

Note: *Partially protected species.

N = 32 hunter-weeks when I did not accompany informants.

With 124 total observed captures, on average one animal is captured for every 153 snare nights. In other words, a hunter with 70 snares will catch one animal roughly every other day. However, fence snares target small animals for home consumption (Table 4.3). Fence snares captured only two animals weighing over one kilogram. Only the more common foot and neck snares target larger marketable animals

(Table 4.4). A snare line of 70 foot and neck snares captures on average one *C. callipygus* and one *C. monticola* each week, or one animal every 2.5 days. Excluding non-marketed species, but taking into account losses of marketable species to decomposition and scavengers, returns per snare night average 9.4 CFA. A snare costs 75 CFA and pays for itself in less than eight days.

Table 4.3: Capture Rates for Fence Snares
(snare nights per animal by species)

<u>Species</u>	<u>Weight</u>	<u>Captures</u>	<u>Rate</u>
<i>Cricetomys emini</i>	0.84	6	178
Birds	0.23	5	213
Small rodents	0.10	5	213
Small carnivores	2.75	2	533
Snake (unidentified)	1.25	1	1,067
All species	0.71	19	56

Note: 1,067 total snare nights. Weight is average for recovered snare captures.

Table 4.4: Capture Rates for Foot and Neck Snares
(snare nights per animal by species)

<u>Species</u>	<u>Weight</u>	<u>Captures</u>	<u>Rate</u>
<i>Cephalophus monticola</i>	4.48	38	469
<i>Cephalophus callipygus</i>	16.46	36	495
<i>Atherurus africanus</i>	2.79	11	1,618
<i>Cephalophus dorsalis</i>	14.20	7	2,543
Rodents	0.73	3	5,934
Small carnivores	2.75	3	5,934
Monkeys	4.00	2	8,902
<i>Potamochoerus porcus</i>	35.00	2	8,902
<i>Cephalophus leucogaster</i>	--	1	17,803
<i>Cephalophus nigrifrons</i>	13.50	1	17,803
<i>Manis tricuspis</i>	1.50	1	17,803
All species	9.63	105	170

Note: 17,803 total snare nights. Weight is average for recovered snare captures.

Age Structure and Sex Ratios⁷

Very few young animals are captured by snares (Table 4.5)--either they do not move about at all, or they follow their mothers who will trip snares first. Young animals also weigh less than adults, and are less likely to trigger snares. However, pregnant females are captured, and when lactating females die their young most likely do not survive: at least two *C. callipygus*, one *C. monticola*, and one *C. nigrifrons* females were lactating. The figures for *C. monticola* differ significantly from the age distribution described by Dubost (1980) in Table 3.3 (Chi-square = 12.68, $p < 0.02$), suggesting that snare captures are biased towards adult blue duikers.

Table 4.5: Age Structure of Animals Captured in Snares
(number of individuals by age class)

	<u>Fetuses</u>	<u>Number of Molars</u>			<u>Subadult</u>	<u>Adult</u>
		<u><1</u>	<u><2</u>	<u><3</u>		
<i>C. monticola</i>	1	0	0	1	4	27
<i>C. callipygus</i>	1	0	0	1	4	23
<i>C. dorsalis</i>	1	1	0	0	1	4
<i>C. leucogaster</i>	0	0	0	0	0	1
<i>C. nigrifrons</i>	0	0	0	0	0	1
<i>A. africanus</i>	1	--	--	--	1	6

Note: I did not dissect uteri, and therefore only recorded fetuses large enough to detect by touch. Actual pregnancy rates may have been considerably higher.

Subadult and adult duikers all have complete dentition (3 molars): animals were classified as subadults if their reproductive organs were not fully developed, or if they were considerably below average adult weights.

⁷For animals that were excessively decomposed or scavenged, no age or reproductive information could be determined.

The limited data suggest that females are captured more frequently for all four game species (Table 4.6). A chi-square test indicates that only the *C. monticola* sex ratio is statistically different from the assumed 1:1 sex ratio (chi-square = 3.33, $p < 0.1$), and snare captures are biased towards females. The case of *C. callipygus* is not statistically significant (chi-square = 0.44) and the sample sizes for the other two species are too small. In some cases males may be stronger, and therefore more likely to escape from snares. Alternatively, females may restrict their movements more to established trails than do males. However, it is also possible that actual adult sex ratios for these species are biased in favor of females.

Table 4.6: Sex Ratios of Animals Captured in Snares
(number of individuals, female/male ratio)

	<u>Female</u>	<u>Male</u>	<u>Ratio</u>
<i>A. africanus</i>	4	3	1.3
<i>C. callipygus</i>	17	12	1.4
<i>C. monticola</i>	20	10	2.0
<i>C. dorsalis</i>	2	1	2.0

Wastage

Cable snares are a wasteful hunting method: over one-quarter of total captures decompose or are eaten by scavengers while the hunter is away (Table 4.7). Scavengers include leopards, golden cats, mongooses, genets, civets,

eagles, duikers,⁸ bush pigs, and ants.⁹ Flies lay eggs on animals in snares before they die, and the maggots accelerate death and decomposition. However, animals caught in foot snares may not die for two days or more depending on their size and the weather: large animals die more slowly, and animals die more quickly from shock and exposure to rain.

Table 4.7: Wastage from Cable Snares
(number and percent of captures
lost to scavengers and decomposition)

<u>Species</u>	<u>Captures</u>	<u>Wastage</u>	
		<u>Number</u>	<u>Percent</u>
<i>Cephalophus monticola</i>	38	8.0	21.1
<i>Cephalophus callipygus</i>	36	11.0	30.6
Rodents	14	2.5	17.9
<i>Atherurus africanus</i>	11	4.0	36.4
<i>Cephalophus dorsalis</i>	7	2.5	35.7
Birds	5	2.0	40.0
Carnivores	5	2.0	40.0
Monkeys	3	1.0	33.3
<i>Potamochoerus porcus</i>	2	0.0	0.0
<i>Cephalophus leucogaster</i>	1	0.5	50.0
<i>Cephalophus nigrifrons</i>	1	0.0	0.0
<i>Manis tricuspis</i>	1	0.0	0.0
Snake	1	0.0	0.0
All species	124	33.5	27.0

Notes: 0.5 animal indicates that part of the animal was recovered.

If on average 27 percent of all snare captures are not recovered, annual wastage for the Bayanga region, based on

⁸Though principally frugivorous, duikers consume small quantities of animal matter.

⁹Although the carnivores benefit from snares by "stealing" captured animals, they too are sometimes captured.

10,552 total captures (see Appendix 6), exceeds 2,800 animals. Losses to scavengers and decomposition are thus a major problem, though both can be reduced by more systematic surveillance. Hunters readily admit this, yet there are often events which keep them in town longer than they expect--illness, holidays or lack of manioc. The sentiment they generally express then is regret that meat or money has been lost, not that animals have died unnecessarily. One hunter, giving up on snare hunting, abandoned his entire string of set snares in the forest. When asked about the animals that might get caught after him, he said "they should have gotten themselves caught while I was there." Most losses occur when the snares go unchecked for more than two days. More systematic surveillance can also reduce injured escapes, as the more time large animals have to fight, the more likely they are to break the cable. Thus informants often say: "if only I had come yesterday, I would have found this animal."

Injured Escapes

Cable snares cause considerable damage in addition to the animals they capture. Over one-third of the animals caught by cable snares break the cable and escape with an injury of some kind: a missing foot or broken leg, an open wound, or a tightened cable noose hanging from the limb. Of the 74 recorded escapes, 65 instances were animals that

broke the cable. On five occasions the escaped animal left a foot in the snare: two *C. callipygus*, one *C. dorsalis*, one *A. africanus* and one *Nandinia binotata*. Three small rats that escaped did so because the snare severed their tail. The data on injured escapes indicate vulnerability by species to snare hunting (Table 4.8).

Table 4.8: Injured Escapes from Cable Snares
(number of animals and percent of encounters)

<u>Species</u>	<u>Esc</u>	<u>Cap</u>	<u>Enc</u>	<u>Vul</u>
<i>Cephalophus callipygus</i> *	19.8	36.0	55.8	64.5
<i>Cephalophus sylvicultor</i> *	8.3	0.0	8.3	0.0
<i>Cephalophus dorsalis</i> *	6.3	7.0	13.3	52.6
Mongoose*	5.0	3.0	8.0	37.5
<i>Tragelaphus euryceros</i> *	3.5	0.0	3.5	0.0
<i>Cephalophus monticola</i> *	3.0	38.0	41.0	92.7
Pangolins	3.0	1.0	4.0	25.0
Rodents	3.0	14.0	17.0	82.4
<i>Atherurus africanus</i>	2.0	11.0	13.0	84.6
<i>Potamochoerus porcus</i> *	2.0	2.0	4.0	50.0
<i>Gorilla gorilla</i> **	1.0	0.0	1.0	0.0
<i>Loxodonta africana</i> **	1.0	0.0	1.0	0.0
Monkeys	1.0	2.0	3.0	66.7
<i>Nandinia binotata</i>	1.0	2.0	3.0	66.7
Birds	0.0	5.0	5.0	100.0
<i>Cephalophus leucogaster</i> *	0.0	1.0	1.0	100.0
<i>Cephalophus nigrifrons</i> **	0.0	1.0	1.0	100.0
Snake (unidentified)	0.0	1.0	1.0	100.0
Unknown	14.0	--	--	--
All species	74	124	198	62.6

Notes: Esc = escapes. Escaped animals were identified by the snare hunters from tracks or other signs. On several occasions they identified the animal as one of two or three possible species: 0.5 animal indicates uncertain among two species, 0.3 animal indicates uncertain among three species. Cap = captures. Enc = total encounters (escapes plus captures). Vul = vulnerability (percent of encounters that are captured).

*Partially protected species. **Fully protected species.

A chi-square test for the four most commonly encountered duikers *C. monticola*, *C. callipygus*, *C. dorsalis* and *C. sylvicultor* reveals that the differences between captures and encounters by species are statistically significant: chi-square = 31.07, $p < 0.01$. The larger animals are more likely to escape from snares, while the smaller animals are more likely to be captured.

Some of the animals that escape may die from their injuries, but others survive even the loss of a limb. Though *T. euryceros* and *C. sylvicultor* were caught by snares several times, they always broke the cable and escaped. Other evidence corroborates this problem: the safari hunters found cables or old wounds on all eight *T. euryceros* that they killed in 1994. One informant also tells of a *C. sylvicultor* he killed in a snare that had a total of nine old cables or wounds, on all four legs. Elephants frequently spring or trample snares:¹⁰ in one case the cable was not found, and the hunter assumed the snare had sprung on the elephant's trunk and injured the animal. The escaped gorilla took the entire cable.

Smaller animals are generally more vulnerable to snares. The pangolin and mongoose escapes are relatively numerous in part because they were caught by the foot in neck snares, where the cable is only a single strand and

¹⁰Some Mossapoula snare hunters said they removed their snares during one period because elephants were springing too many.

therefore easier to break. The only smaller animals that escaped were three rats that lost their tails to the snare. Small carnivores and *A. africanus* will escape from snares by chewing off their foot, unless the snare lifts them off the ground: two of the *A. africanus* caught by net hunters were missing a foot for this reason. These data suggest, and informants confirm, that *C. dorsalis* is a stronger animal than *C. callipygus*, and more likely to escape from snares. Nearly one-fourth of *C. dorsalis* captured have previous cable snare injuries (Table 4.9), the most serious being an individual missing two feet. Two other animals, one *A. africanus* and one *C. dorsalis*, also had two injured limbs. The larger the animal, the fewer total captures, but the greater the proportion with previous injuries from cable snares.

Table 4.9: Snare Injuries on Captured Animals
(number of animals and percent of total captures)

	<u>Captures</u>	<u>Wound</u>	<u>Injuries</u> <u>Cable</u> <u>on foot</u>	<u>Foot</u> <u>missing</u>	<u>Percent</u> <u>injured</u>
<i>A. africanus</i>	77	2	0	2	4
<i>C. callipygus</i>	49	2	0	1	6
<i>C. dorsalis</i>	45	4	4	5	24
<i>P. porcus</i>	2	0	0	1	50

Note: Total captures include Bayanga snare hunting (where the carcass was recovered) and Mossapoula net hunting.

These data suggest that for every three animals captured, two more escape injured. Based on estimated annual snare captures of 10,552 animals for Bayanga hunters,

cable snare hunting in this area inflicts nearly 7,000 injuries each year.

Protected Species

I recorded three instances, in 198 encounters, of fully protected species killed or injured by cable snares: one elephant, one gorilla and one *C. nigrifrons*. Although less than two percent of encounters are with protected species, snares are placed on trails that any animal uses and therefore all species are vulnerable. Informants speak of capturing or injuring chimpanzees, gorillas, leopards, crocodiles, etc. Hunters do not intentionally target protected species, but it is impossible to hunt selectively with cable snares.¹¹ Protected species may be present only in very low densities, such that even low offtake levels from cable snares may have serious implications for the population. Injuries can also reduce reproduction rates, by reducing an animal's ability to find a mate or raise young. Mammals with large home ranges and low population densities are particularly vulnerable.

¹¹An exception is the case of snares set along crocodile trails through marshes.

Sustainability of Snare Harvest Rates

Conservationists generally assume that cable snare hunting for markets is unsustainable. The following calculations are based on extrapolations from limited data, and according to assumptions that may be unjustified. Snare hunting is illegal, and the behavior of hunters who did not allow me to accompany them may differ from that of the hunters I observed. Sustainable harvest rates are based on theories and data from other species, while measurements of population densities for terrestrial forest wildlife remain problematic. Furthermore, hunting patterns change over time in response to employment conditions, park enforcement, population growth, and bushmeat market opportunities. Wildlife populations may also fluctuate in response to environmental conditions and hunting pressure. Despite the caveats cited above, conservation and development proponents both seek to know whether snare hunting is sustainable. The following discussion uses the available data to address this question. Fence snares, which target small unmarketed animals, are not considered below.

Assuming that 60 cable snare hunters in Bayanga hunt with 70 snares apiece, total annual snare hunting amounts to 1,533,000 snare nights. Based on 105 animals captured during 17,803 observed snare nights, total annual harvesting for Bayanga exceeds 9,300 animals. Additional figures are from the neighborhood and market/export survey data

described in Chapter 3, extrapolating from the number of observation days to annual offtakes over 365 days (see Appendix 6 for calculations). However, neither of the latter two surveys was comprehensive. If the predictions from observed captures are correct for duikers, then the market/export survey data reported below represent only 73 percent of actual captures.

Total biomass harvested with snares from the Bayanga region each year exceeds 125 kilograms per square kilometer on average (Table 4.10). Duikers comprise over 60 percent of the harvested biomass. If gun harvests are included, total annual bushmeat offtake exceeds 185 kilograms per square kilometer. These figures do not include animals that escape but that die from injuries. Bayanga harvests therefore have serious ecological implications: they remove a considerable proportion of mammals, particularly terrestrial frugivores, from the ecosystem. In addition, 27 percent of snare harvests are lost to decomposition and scavengers, equivalent to 2,850 animals and 33,911 kilograms per year.

Table 4.10: Annual Biomass Harvest by Snares and Guns
(number of animals and kilograms by species)

<u>Species</u>	<u>Weight</u>	<u>Snares only</u>		<u>Snares and Guns</u>	
		<u>Number</u>	<u>Biomass</u>	<u>Number</u>	<u>Biomass</u>
*Red duikers	16.59	3,875	64,285	5,585	92,662
<i>C. monticola</i>	4.68	3,272	15,314	4,656	21,792
Monkeys	8.00	1,060	8,481	1,982	15,857
<i>A. africanus</i>	3.19	947	3,022	947	3,022
<i>P. porcus</i>	60.00	346	20,783	483	28,960
Other	12.59	1,051	13,229	1,190	23,868
All species	--	10,552	125,599	14,844	186,858

Notes: See Appendix 6 for calculations of annual harvests. Biomass is based on average adult weights, in the Bayanga region if data are available. *Red duikers include *C. callipygus*, *C. dorsalis*, *C. leucogaster*, and *C. nigrifrons*.

Per capita bushmeat consumption for Bayanga can be estimated from the data above, given the following assumptions: only 73 percent of meat harvested by snares is recovered, 60 percent of total biomass is edible meat, and 30 percent of Bayanga bushmeat production is exported. Snare hunting alone produces 15.4 kilograms of edible meat each year for each of the 2,500 Bayanga residents. If gun harvests are included, annual per capita consumption rises to 25.7 kilograms.

Assuming a hunting area of 1,000 square kilometers for Bayanga snare hunters, actual harvest rates for the four primary game species can be compared to predicted sustainable harvest rates (see Appendix 3). However, estimates of sustainable harvest rates vary widely, as do estimates of population densities. Therefore Table 4.11 presents a range of estimates for each parameter.

C. callipygus harvests are unsustainable according to all estimated densities and sustainable harvest rates. However, both census methods probably underestimate densities for this species. Nevertheless, the relatively high harvest rate suggests that *C. callipygus* is most in danger of overexploitation by cable snare hunters. The census methods also probably underestimate *A. africanus* densities, and harvests are most likely sustainable for this species.

Table 4.11: Bayanga Annual Snare Harvest Rates
(individuals per square kilometer by species)

<u>Species</u>	<u>SHR (%)</u>	<u>D</u>	<u>SH*</u>	<u>H</u>
<i>A. africanus</i>	9.9-67.5	2.7-17.6	0.27-11.88	1.0
<i>C. monticola</i>	2.3-34.4	10.5-66.9	0.24-23.01	3.3
<i>C. dorsalis</i>	1.6-21.3	0.3-6.6	0.01-1.13	0.6
<i>C. callipygus</i>	1.2-21.8	0.9-3.7	0.01-0.81	3.1

Notes: See Appendix 3 for calculations of sustainable harvest rates. Bayanga snare hunting range is 1,000 km².

SH is the range of sustainable harvest rates predicted in theory, as a percentage of the population (see Chapter 3).

D is the range of estimated population densities (animals/km²) in the Bayanga region according to line transect surveys and net hunt encounters (see Chapter 3).

SH* is the number of individuals per square kilometer that may be sustainably harvested, given SH and D.

H is the number of individuals harvested per square kilometer by snare hunters.

In the other two cases, actual harvest rates lie towards the lower end of the range of sustainable harvests: harvests are sustainable according to the least conservative density estimates and predicted sustainable harvest rates, but unsustainable according to the most conservative

estimates for these two parameters. Therefore, current snare harvests may be sustainable for *C. monticola* and *C. dorsalis*. But overhunting is likely if population densities decline or hunting levels increase, or if the upper limits of SH* are incorrect.

However, snare hunting is not practiced exclusively in a given area. Gun hunters and net hunters also hunt throughout the Bayanga region. The following chapter examines net hunting by Mossapoula residents. Based on the project's survey of bushmeat availability in local markets and bushmeat exports, combined with the neighborhood survey data on the relative importance of snares versus guns in supplying bushmeat, some rough estimates are possible (Table 4.12).¹²

¹²Although there are only eight legal guns in Bayanga, they can be extremely productive if ammunition is available: hunters can hunt all day for primates and duikers (calling duikers by imitating their distress calls), and all night for duikers and other terrestrial animals using headlamps. Given the abundance of game in the Bayanga region, they can kill several animals each day and each night.

Table 4.12: Bayanga Annual Snare and Gun Harvest Rates
(individuals per square kilometer by species)

<u>Species</u>	<u>Snares</u>	<u>Guns</u>	<u>Combined</u>	<u>SH*</u>
<i>C. monticola</i>	3.3	1.4	4.7	0.24-23.01
<i>C. callipygus</i>	3.1	1.4	4.5	0.01-0.81
<i>A. africanus</i>	1.0	?	1.0	0.27-11.88
<i>C. dorsalis</i>	0.6	0.3	0.9	0.01-1.13

Notes: I have no information on *A. africanus* harvests by gun hunters.

SH* is the number of individuals per square kilometer that may be sustainably harvested, according to estimated population densities and sustainable harvest rates.

Based on the matrix of sustainable harvest levels presented in Appendix 3, I have calculated an index of sustainability, defined as the number of cells in the matrix less than or equal to the actual harvest divided by the total number of cells. The higher this index, the more likely that hunting is unsustainable (Table 4.13).

Table 4.13: Sustainability Index by Species
and Hunting Method

	<u>Snares</u>	<u>Guns</u>	<u>Combined Hunting</u>
<i>C. monticola</i>	0.667	0.438	0.833
<i>C. callipygus</i>	1.000	1.000	1.000
<i>A. africanus</i>	0.333	?	0.333
<i>C. dorsalis</i>	0.938	0.833	0.938

Notes: See Appendix 3 for the matrix of sustainable harvest levels in the Bayanga region, according to line transect survey and net hunt encounter density estimates, and to theoretical sustainable harvest rates.

The index of sustainability is equal to the number of cell values in the matrix less than or equal to the actual harvest divided by the total number of cells for each species. The higher the index, the more likely that hunting is unsustainable.

Each method alone is likely to overexploit *C. callipygus*: combined exploitation is almost certainly excessive. *C.*

dorsalis may also be overhunted, particularly in areas where both hunting methods are used. Hunting by snares and guns may be sustainable for *C. monticola* and *A. africanus*.

Snare hunting has probably been practiced at these levels since the major human population immigrations with the arrival of the logging company in 1972. Therefore current hunting practices and yields reflect over two decades of hunting pressure. However, during this time hunting pressure has varied from year to year according to alternative economic opportunities, movements of human populations, conservation enforcement, etc. Local hunters have responded to these changes by alternating among subsistence and economic activities, and by altering the areas where they hunt. Therefore they do not consistently report continuous declines in wildlife populations.

Although wildlife populations in the Bayanga region may have declined under hunting pressure, the primary game species have not been exterminated. If they have stabilized at new and lower levels, then harvesting is sustainable. If the upper estimates of sustainable harvest rates are correct, the data above suggest that snare harvests of *C. monticola* and *A. africanus* may be sustainable. If *C. callipygus* and *C. dorsalis* harvests are sustainable as well, then actual population densities are higher than estimated, or reproductive rates are higher than predicted, or populations are being maintained by immigration from

unhunted areas. However, all of the Bayanga region is hunted--the closest areas that are possibly unhunted lie in Congo, over 30 kilometers east of Bayanga. It is uncertain whether duikers, given their small home ranges, can disperse as far as 30 kilometers to repopulate continuously hunted areas. Furthermore, immigration or higher reproductive rates would result in relatively high numbers of young animals in the hunted population. But hunters capture very few young animals. It is therefore possible that populations are systematically overhunted and have been in continuous decline for two decades. In attempting sustainable harvests, given the high degree of uncertainty, the more conservative oftakes are the safer alternative.

Economic Importance of Cable Snare Hunting

This section examines the economic importance of cable snare hunting, according to the amount of employment it provides, and the income it generates, relative to alternative economic and subsistence opportunities for Bayanga residents. Employment is determined according to Bayanga censuses, while income is based on snare hunting yields and the local market prices for bushmeat.

Employment

Most Bayanga residents are immigrants--over 85 percent were born elsewhere. They have been drawn to Bayanga for economic opportunities: the logging company, the Dzanga-Sangha project, coffee plantations and diamond mining. However, virtually all ethnic groups in CAR have a hunting tradition. Hunting is historically for them, wherever they originally come from, one of several subsistence and economic activities including gathering, fishing, and agriculture. Therefore, if they do not find wage labor in Bayanga, they pursue whichever of these alternatives is most successful, or a combination of activities. They do not fear the forest, and learn how to exploit it through cable snare hunting as well as gathering. Many know how to set cable snares before they come to Bayanga. Others soon learn by accompanying other hunters. Employment with the logging company acquaints people with the forest: hunting often begins while logging is taking place. The roads and skidder tracks remain long after logging stops, serving as foot trails for snare hunters.

Most of my 17 informants first came to Bayanga because of the logging company: two were hired elsewhere by Slovenia-Bois and relocated to Bayanga, five came looking for work and were hired, and six came with a family member who was employed. Two others followed family members who worked for the government and the Baptist church

respectively. They now remain in Bayanga because they hope to be re-hired by the logging company, they were owed back-pay, they have planted fields, or their family remains in Bayanga. However, not all 85 of those identified as snare hunters (see Chapter 3) may actually be hunting at any given time, as individuals continuously shift among occupations such as hunting, fishing, raffia wine tapping, diamond mining, raffia shingle-making, etc. (Figure 4.4).

For example, one of my informants snare hunted until February 1994, then went to the diamond fields at Yobé, then returned to snare hunting in May, abandoning it again in June, returned to snare hunting again in October, and abandoned hunting in December (example 5). Another informant hunted for two months, then fished for five months, and later moved away from Bayanga (example 6). A third informant was caught by guards and lost most of his snares, continued hunting with the remainder, then quit when he heard the logging company might hire him, and took up raffia shingle-making in the interim (example 7). A fourth person quit hunting and moved to Salo when he was hired by the logging company there (example 8). Snare hunting can therefore be a full-time activity, but one that is pursued only intermittently.

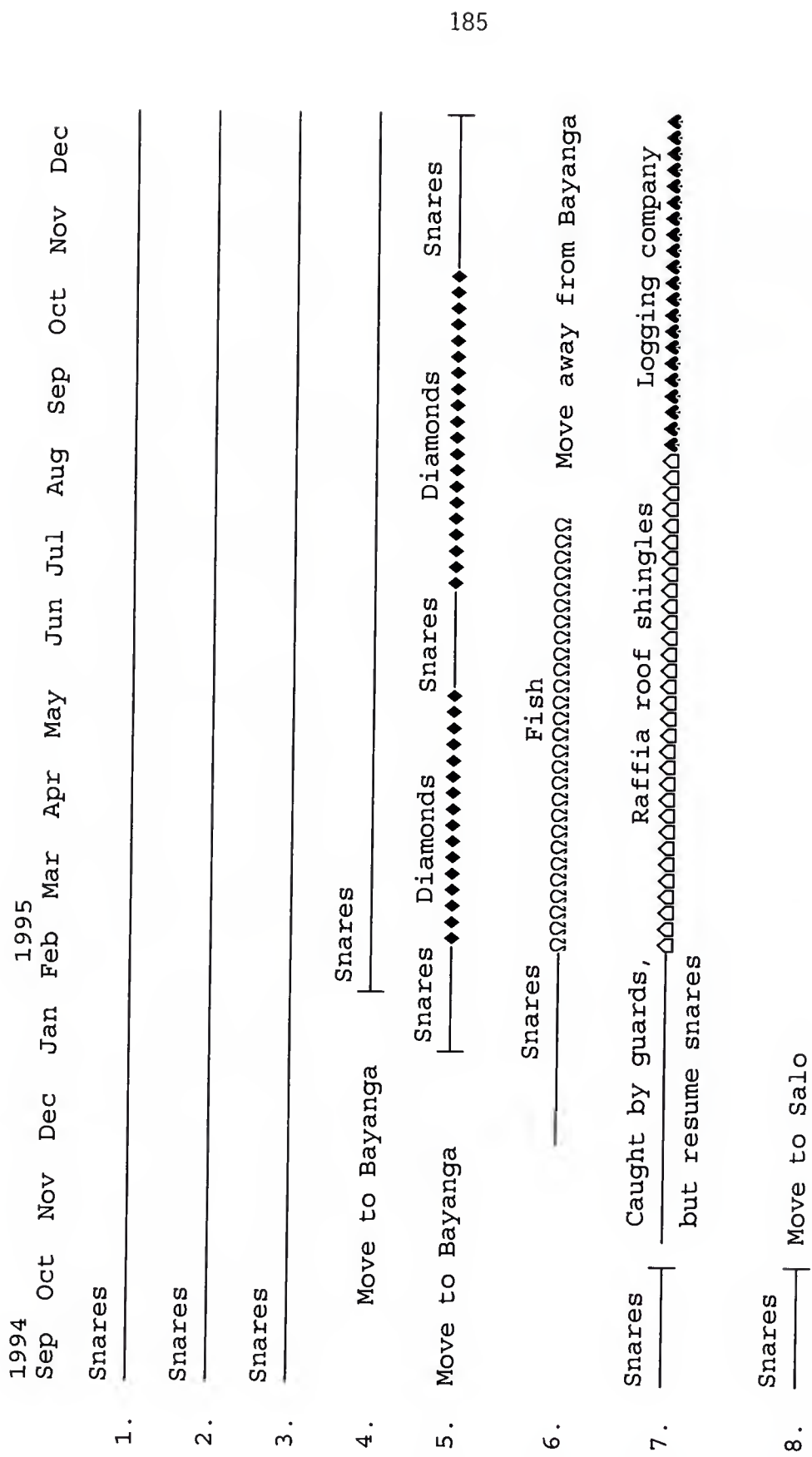


Figure 4.4: Informant Occupation Time-Lines

Only three informants hunted continuously from September, 1993 through December, 1994. Snare hunting can also be a part-time activity: for example, people who work for the project or the logging company (example 12) set some snares near town that they can check after work or on weekends. Two other informants tap raffia wine and run snare lines simultaneously (examples 13 and 14). They have partners in each activity who can take over the work while they are occupied with the other.

Even those hunting continuously spend at most three days in the forest, including travel to and from Bayanga, for every two in Bayanga. This corresponds to roughly 220 work days per year, although some of the days in hunting camps are not spent directly in snare hunting activities.

Income

Estimated income from snare hunting is based on the standard market prices for bushmeat in Table 4.14. There are no standard prices or cuts for large animals like bush pigs, and pieces weighing 1-5 kilograms sell for 500-3,000 CFA. Prices increased following devaluation in January 1994, despite the mayor's attempts to restrict price increases by confiscating meat being sold at the new prices.

Table 4.14: Bushmeat Market Prices in Bayanga
(CFA francs, before and after devaluation)

	<u>Before</u> <u>Devaluation</u>	<u>After</u> <u>Devaluation</u>
<i>A. africanus</i>	1,000	1,500
<i>C. monticola</i>		
Half	500	750
Total value	1,000	1,500
Monkeys		
Half	1,000	1,500
Total value	2,000	3,000
Red duikers		
Forelimb	700	900
Hindlimb	800	1,000
Total value	3,000	3,800

Notes: Red duikers include *C. callipygus*, *C. dorsalis*, *C. leucogaster*, and *C. nigrifrons*. *A. africanus* are sold whole, whereas other species are sold in pieces.

Weekly yields from snare hunting average 26.9 kilograms per hunter. Assuming that all recovered and marketable meat is sold, at post-devaluation prices, weekly yields average 6,000 CFA per hunter from snares. One week the only animals captured were unrecoverable, and returns were therefore nil. Maximum weekly returns per hunter from snare hunting were 60.3 kg of meat, and 18,200 CFA (Table 4.15). Four hunters also reported their returns during weeks when I did not accompany them. During 32 reported hunter-weeks, weekly returns averaged 4,469 CFA.

Table 4.15: Weekly Returns from Snare Hunting
(per person, N = 29 weeks)

	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>
Kgs	0.00-60.25	26.85	17.79
Edible meat	0.00-36.15	16.11	10.68
Calories	0-65,070	28,998	19,215.86
CFA	0-16,400	5,403	3,978.93

Notes: Returns are based on recovered animals only. Edible "meat" is estimated to be 60 percent of the carcass weight (Ichikawa, 1983; Martin, 1985; Tanno, 1976). 100 grams of meat contain approximately 180 calories (Bailey and Aunger, 1989; Bailey and Peacock, 1988). \$US1 $\approx$ 580 CFA.

During 12 weeks of observed hunting over 11 months, my principal informant earned 72,800 CFA, which corresponds to an annual income from snare hunting of 315,000 CFA. His monthly income of 26,000 CFA is roughly comparable to the 22,000-30,000 CFA that full-time project employees earn. The official minimum wage rose from 650 to 850 CFA per day after devaluation, or 16,000 to 22,000 CFA per month, although the logging company pays some workers only 200-300 CFA per day. Average weekly yields from snare hunting therefore exceed the official minimum wage. Snare hunting thus provides an income that is adequate to keep hunters at a level roughly even with their neighbors.

However, snare hunting is seen by most as a more difficult occupation: hunters must sleep in the forest, and carry manioc from town and meat back to town. Snare hunting is also more risky because of game guards, dangerous animals, and theft of snares and equipment by other hunters.

Finally, snare hunting yields are inconsistent and unreliable: the coefficient of variation for returns in kilograms is 1.51, and for returns in CFA is 1.36.

Therefore, people do not consider snare hunting to be a permanent occupation: most seek full-time formal employment and abandon snare hunting when they find such work in Bayanga or elsewhere. The lure of the diamond fields also grows stronger, attracting snare hunters with the promise of bigger pay-offs.

People do not move to Bayanga for the snare hunting opportunities. But if they are unable to find alternative employment snare hunting can provide sufficient income to sustain them, in addition to dietary supplements from portions of snared animals that are not sold. Unless yields or prices rise significantly, snare hunting will not draw people away from other occupations. People say that yields are much better in certain areas near or across the Congo border, over a day's walk from Bayanga. However, my informants no longer hunt that far away because they say it is too much work to carry manioc and meat that far.¹³

¹³They are also aware that a park now exists in Congo, but do not cite fear of Congolese park guards as a deterrent.

Table 4.16: Estimated Annual Bayanga Bushmeat Production
(number of animals and value in CFA francs)

<u>Species</u>	<u>Value</u>	<u>Snares only</u>		<u>Number</u>	<u>Percent</u>
		<u>Number</u>	<u>Value</u>	<u>Exported</u>	<u>Exported</u>
Red duikers	3,800	3,875	10,748,997	1,029	26.6
<i>C. monticola</i>	1,500	3,272	3,582,999	860	26.3
Monkeys	3,000	1,060	2,321,759	258	24.3
<i>A. africanus</i>	1,500	947	1,037,184	0	0.0
<i>P. porcus</i>	10,000	346	2,528,608	84	24.3
Other	2,690	707	1,389,729	45	6.4
All species	--	10,208	21,609,275	2,276	22.3

<u>Species</u>	<u>Value</u>	<u>Snares and guns</u>		<u>Number</u>	<u>Percent</u>
		<u>Number</u>	<u>Value</u>	<u>Exported</u>	<u>Exported</u>
Red duikers	3,800	5,585	17,248,835	1,639	29.3
<i>C. monticola</i>	1,500	4,656	5,659,435	1,348	29.0
Monkeys	3,000	1,982	5,087,472	578	29.2
<i>A. africanus</i>	1,500	947	1,037,184	0	0.0
<i>P. porcus</i>	10,000	483	3,891,365	128	26.5
Other	2,690	846	3,026,428	100	11.8
All species	--	14,500	35,950,718	3,793	26.2

Notes: See Appendix 6 for calculations. Value is at post-devaluation prices (\$US1 ≈ 580 CFA), assuming only 73 percent of meat from snares is recovered.

Prices could rise if demand for bushmeat increases from urban centers such as Nola and Berberati, or from the diamond fields. Hunters supplying Nola and the Yobé diamond fields are exploiting the northern portions of the Dzanga-Sangha Reserve. Up to now, the project guards have limited the traffic in meat from Bayanga itself, but despite the restrictions roughly one-fourth of bushmeat production in Bayanga is exported (Table 4.16).

Snare hunting provides major contributions to the Bayanga economy as a whole. According to these aggregate data from bushmeat market surveys, an estimated 60 snare

hunters in Bayanga earn over 360,000 CFA apiece each year, or 30,000 CFA each month. These figures are only slightly higher than my principal informant's observed annual earnings of 315,000 CFA. The opportunity to export meat means that snare hunters' earning potential is not limited by the Bayanga market demand. If exports were eliminated by park guard surveillance, snare hunter earnings would presumably decline by one-fourth, assuming that the current supply exceeds local consumption levels. Snare hunting may in turn decline. However, because meat that is not sold is eaten by the hunter's family, an alternative result could be an improvement in local diets with no change in hunting pressure.

Although snare hunters abandon or reduce hunting activities when they are hired by the logging company or the project, the increase in formal employment opportunities induces further immigration by people seeking work and joining employed family members. These immigrants are likely to hunt to support themselves. The demand for meat also increases with the growing human population, and the increasing amount of money in the local economy. Meat prices may also rise, and these factors combined will likely result in increased hunting. Loggers also continue to hunt in areas where they are cutting timber. Increases in diamond mining activity similarly increase the amount of

money in the local economy, the local population, and the demand for meat.

Comparative Data

Studies of bushmeat markets in west and central Africa (Anadu et al., 1988; Colyn et al., 1987; Falconer, 1990; Martin, 1983; Steel, 1994) describe large quantities of animals for sale along main roads and in major towns, as well as in local markets. Much of this meat comes from snare hunters. In Nigeria, bushmeat sales along roads comprise over 20 mammal species (Anadu et al., 1988; Martin, 1983). Tables 4.17 and 4.18 provide comparative data on bushmeat consumption and snare captures from other African forests.

In other countries where human population densities are higher, and particularly near urban areas, rodents become a major source of bushmeat because ungulates are exterminated. Primates also become important game species in areas where guns are more widely used than they are in Bayanga.¹⁴ In African forests from Liberia to Zaïre, snare hunting and the bushmeat trade focus on the most abundant small and medium-sized terrestrial mammals, especially the duikers (Ajayi, 1979; Davies, 1987; Dei, 1989; Falconer, 1990; Laurent,

¹⁴Lahm (1993) reports one shotgun for every 1.2 households in Gabon, compared to at least 20 households per gun in Bayanga (assuming twelve illegal guns in addition to eight legal ones).

1992; Martin, 1983; Ntiamoa-Baidu, 1987; Sato, 1983; Wilson, 1987). In Bayanga, duikers comprise 70 percent of captures, 64 percent of biomass harvested, and 67 percent of revenues from snare hunting.

Table 4.17: Comparative Bushmeat Consumption
(percent of animals by species)

	<u>Bayanga^a</u>		<u>Gabon^b</u>		<u>Gabon^c</u>	<u>Congo^d</u>	
			<u>(1)</u>	<u>(2)</u>		<u>(1)</u>	<u>(2)</u>
Ungulates	78		40	51	81	--	--
Duikers	71		34	43	70	47	38
Red duikers	38		14	15	15	6	3
<i>C. monticola</i>	32		20	27	55	41	35
<i>P. porcus</i>	3		3	4	9	--	1
Primates	10		20	15	12	8	3
Rodents	0		27	13	--	--	23
<i>A. africanus</i>	0		27	12	6	35	20
Carnivores	0		2	3	--	3	1

	<u>Zaire^e</u>		<u>Nigeria^f</u>	<u>Nigeria^g</u>	<u>Eq Guinea^h</u>	
	<u>(1)</u>	<u>(2)</u>			<u>(1)</u>	<u>(2)</u>
Ungulates	13	44	32	18	36	41
Duikers	12	--	26	11	33	22
Red duikers	--	--	--	--	4	7
<i>C. monticola</i>	8	--	--	--	29	15
<i>P. porcus</i>	--	--	3	3	--	1
Primates	21	16	9	16	25	22
Rodents	44	36	48	61	37	30
<i>A. africanus</i>	--	--	19	6	15	24
Carnivores	15	--	4	1	--	2

Note: Data are from surveys of animals for sale in urban markets or along main roads.

Sources: ^aNoss, see above; ^bSteel, 1994 (1) Libreville market, (2) other urban markets; ^cLahm, 1993a; ^dWilson, 1990 (1) roadside, (2) urban markets; ^eColyn et al., 1987 (1) total consumption, (2) urban markets; ^fMartin, 1983; ^gAnadu et al., 1988; ^hJuste et al., 1995.

Table 4.18: Comparative Snare Captures
(percent of animals by species)

	<u>Bayanga</u>	<u>Gabon</u>	<u>Zaire</u>	<u>Cameroon</u>
Ungulates	70	58	84	64
Duikers	68	50	77	54
Red duikers	37	12	47	30
<i>C. callipygus</i>	29	4	--	26
<i>C. dorsalis</i>	6	6	20	4
<i>C. leucogaster</i>	1	1	8	--
<i>C. nigrifrons</i>	1	1	19	--
<i>C. monticola</i>	31	37	30	24
<i>P. porcus</i>	2	2	--	5
<i>H. meinertzhageni</i>	--	--	3	--
<i>H. aquaticus</i>	--	--	4	4
Rodents	20	14	--	30
<i>A. africanus</i>	9	11	3	24
Carnivores	5	5	14	--
Primates	2	19	--	--

Note: Data are from observed and reported captures by snare hunters.

Sources: For Gabon: Lahm, 1993a; 1993b. For Zaire: Wilkie, 1989. For Cameroon: Infield, 1988.¹⁵

Research in Cameroon finds that snare hunting provides 18 percent of village income (Infield, 1988). Estimated annual returns per snare hunter are higher in Bayanga than in western Cameroon or Gabon (Table 4.19). However, firearms are more common in Cameroon and Gabon, and total hunting returns are therefore higher: an estimated 125 kgs per resident per year in Cameroon (Infield, 1988), compared to 75 kgs per resident per year in Bayanga. Annual returns in CFA/hunter, when gun hunting is included, are estimated at an average of 350,000 CFA in Cameroon. Bayanga snare hunters earn approximately the same income. But hunting is

¹⁵According to Payne (1992), Infield confuses *C. dorsalis* with *C. ogilbyi*, and *C. ogilbyi* is a race of *C. callipygus*.

more intensive in Cameroon, averaging 12.5 duikers/km²/year or 137 kgs/km²/year in the Korup region, compared to 7.1 duikers/km²/year or 80 kgs/km²/year in the Bayanga region.

Table 4.19: Comparative Annual Snare Hunting Returns
(total animals and CFA francs per hunter)

	<u>Bayanga</u>	<u>Cameroon</u>	<u>Gabon</u>
Red duikers	65	23	47
<i>C. monticola</i>	55	6	15
<i>A. africanus</i>	16	6	14
Other	41	10	50
Total Animals	176	46	126
Total CFA francs	360,000	60,000-75,000	--

Sources: For Cameroon: Infield, 1988. For Gabon: Lahm, 1993a.

Across central Africa, individual hunters maintain 15-500 snares apiece, inspect snares every 2 or 3 days, and capture 3-30 animals each week (Almquist, 1992; Infield, 1988; Lahm, 1993a; Wilson and Wilson, 1991). Some of the hunters with extremely high numbers of snares are professional hunters supplying urban markets. Data from Gabon on animals killed by snares and guns support the Bayanga data indicating that female duikers are either more abundant, or are more vulnerable to hunters: 1.3:1 female to male captures for *C. monticola*, and 1.1:1 for red duikers. One-half to two-thirds of captured animals are sold (Lahm, 1993a).

Table 4.20: Comparative Snare Hunting Yields
(number of animals and snare nights per capture)

Species	<u>Bayanga</u>		<u>Zaire</u>	
	<u>Number</u>	<u>Rate</u>	<u>Number</u>	<u>Rate</u>
<i>C. monticola</i>	38	469	1	9,680
<i>C. callipygus</i>	36	495	2	4,840
<i>A. africanus</i>	11	1,618	4	2,420
<i>C. dorsalis</i>	7	2,543	1	9,680
<i>P. porcus</i>	2	8,902	1	9,680
<i>C. leucogaster</i>	1	17,803	--	--
<i>C. nigrifrons</i>	1	17,803	2	4,840
<i>H. aquaticus</i>	--	--	5	1,936
Other	9	1,978	--	--
All species	105	170	16	605

Notes: Rate is the number of snare nights per capture, based on 17,803 total snare nights in the Bayanga case, and 9,680 total snare nights in the Zaire case.¹⁶

Source: For Zaire: Sato, 1993.

More detailed information is available from Equateur province in Zaire. Sato (1983) records snare hunting activities for four men and one boy on 57 observation days.¹⁷ Hunters used on average 50 snares, setting them between 0.5 and 6.0 kilometers from the settlement, and visiting them every three or four days. Sixteen animals were captured, including six duikers (Table 4.20). The small data set from Zaire describes snare returns that are much lower than those in the Bayanga region, except for the black-fronted duiker *C. nigrifrons* and the water chevrotain

¹⁶Sato does not calculate snare nights. I do so by multiplying the number of hunters by the number of observation days (57 for the men, 14 for the boy) by the number of snares per person (excluding an estimated 10 snares that have sprung accidentally each visit).

¹⁷He only accompanied individuals on four occasions.

Hyemoschus aquaticus. These two species frequent riverine and marsh forest which the hunters I observed did not exploit.

Conclusion

As is the case elsewhere in African forests, hunting provides food and income, often to complement farming, and is not the sole occupation (Asibey, 1980; Dei, 1989; Oates, 1995). When individuals find more reliable long-term employment they abandon hunting (Infield, 1988). However, the extra meat and income from hunting facilitate human inhabitation and exploitation of forest areas (Redford, 1992). Snare hunting is an important method by which individuals and the Bayanga community as a whole, diversify income and subsistence strategies. However, since they exploit a range of economic opportunities including hunting, the elimination of wildlife resources is not critical because they will then focus on other activities.

Snare hunting techniques are adapted to both the ecological and socioeconomic conditions. Terrestrial mammals use visible trails, and are relatively abundant in the Bayanga region. Snare hunting can be practiced by one or more individuals, with a minimum capital investment. Once they are set, snares can be checked at one's convenience, thus they are compatible with other economic

activities such as farming and formal employment.¹⁸ Snare hunting provides sufficient income and subsistence returns for hunters to continue using this method.

However, snares are ecologically destructive: data suggest that snare hunters in the Bayanga region are overhunting the Peters duiker *C. callipygus*. Exploitation of the other three important game species may be sustainable, if the least conservative estimates for population density and sustainable harvest rates are correct. But in addition to the animals harvested for consumption or sale, many others escape and may subsequently die from injuries. Rare and protected animals are captured or injured as well. One-fourth of the animals killed in snares rot or are lost to scavengers. These losses could be reduced by more systematic surveillance: if the snares are checked every day no meat will rot, fewer animals will be taken by scavengers, and fewer animals will escape. The longer an animal fights in the snare, the more likely it is to free itself, albeit with injuries.

Cable snares are illegal in CAR, and in the Bayanga region the Dzanga-Sangha project game guards arrest hunters and confiscate their snares. Wildlife "management" seeks to eliminate this hunting method altogether. However, research

¹⁸The principal local food crop is manioc, which requires little attention after planting. It too can be harvested at one's convenience, or left in the ground for months.

in southern Africa on the use of cable snares for live capture suggests that the method can be adapted to increase selectivity and reduce waste (Mossman, 1989; Mossman et al., 1963). Of particular relevance to the Bayanga region is a method of tying the cable by which the noose releases when the cable breaks, rather than remaining tightly attached to the animal's leg.

The following chapter examines in turn a hunting method that is legal within the Dzanga-Sangha Reserve, though not in the Dzanga-Ndoki Park, namely communal net hunting.

CHAPTER 5 COMMUNAL NET HUNTING IN MOSSAPOULA

Following the outline of the preceding chapter, this chapter analyzes the second major hunting practice in the Bayanga region: communal net hunting. Research focused on the BaAka village of Mossapoula, located five kilometers north of Bayanga. The first two sections describe the research methodology and the hunting method respectively. The following sections analyze the two research questions: 1) what are the impacts of net hunting on wildlife populations? and 2) what is the economic importance of net hunting for Mossapoula residents? Of particular importance are the sustainability of net hunt harvests, and the relationships between net hunting and other subsistence and economic activities. Two important subjects treated in separate sections are the role of women in net hunting, and seasonal forest hunting camps. The chapter concludes with comparative data from other research on net hunting in Central African forests.

Communal net hunting is the principal hunting method practiced by the BaAka residents of Mossapoula. Crossbow hunting has been virtually abandoned by Mossapoula hunters. Only three men continue to hunt with crossbows, and they hunt infrequently. Others say they have sold their

crossbows to tourists, and the only crossbows that I saw being made during the research period were for sale to tourists. Group spear hunting for large game was not practiced at all by Mossapoula hunters during the research period. However, the technique is still practiced in Yandoumbé, and Mossapoula may only lack individuals with the special skills necessary for group spear hunting.

BaAka men traditionally hunted with many types of snares and traps. But cable snares have replaced more traditional snare methods and materials. Some snares are set near Mossapoula, and are checked on day trips, but others require overnight visits to forest camps. In 1994, 21 of 73 Mossapoula men, or 29 percent, used cable snares, each person reportedly owning on average 19 snares (range 7-60, $SD \pm 12.74$).¹ Several individuals are occasionally hired to hunt with a gun for someone from Bayanga or elsewhere, but the meat belongs to the gun owner and the hunter receives only a small wage. During the observation period four men hunted with guns, for a total of 24 person days.

Net hunting, recognized by the project and by national law as a "traditional" hunting method, is permitted in the Dzanga-Sangha Special Reserve. In order to study communal net hunting, I focused on the village of Mossapoula, located

¹In comparison, less than 20 percent of Bayanga men use snares ($\chi^2 = 1.65$, $p < 0.2$), but each Bayanga snare hunter sets on average 70 snares ($t = 11.47$, $p < 0.01$).

five kilometers north of Bayanga. With roughly 300 inhabitants, Mossapoula is the largest BaAka settlement within the Dzanga-Sangha Reserve. It is also the settlement whose hunting range has been most severely reduced by the creation of the Dzanga-Ndoki National Park.

Methodology

I visited Mossapoula every day during week-long periods (Monday-Friday). I never asked that people hunt on my behalf, but waited to see if a hunt was organized, and accompanied the hunters. However, it is possible that my presence and interest in net hunting at times encouraged people to hunt. Unfortunately, as my principal research method was to observe net hunts, it was impossible to avoid this potential bias. The following examples illustrate why I wanted to observe what people do, rather than report what they say: once when I asked if Mossapoula hunters ever crossed a certain logging road, they said no, but then crossed it two days later. Another hunter said that the BaAka do not kill female animals because if they did there would soon be no more animals in the forest. One week later he himself killed a female blue duiker caught in a net. In addition, when I asked individuals how many animals the net hunting group had killed on days when I was not present, I received several different answers.

I collected data on 90 observation days during 18 weeks over a 12-month period from December 1993 to November 1994 (see Appendix 7). I accompanied 58 of the 76 net hunts that took place during the observation days. The exceptions were of two types. First, the seven demonstration hunts organized on behalf of paying tourists differed in objective, character, and composition from regular day hunts. Tourists usually take about ten young men, and hunt for 1-2 hours at most, until they kill a couple animals. These net hunters are more interested in the 5,000 CFA fee paid to the group than in the meat obtained. Second, on eleven days there were two separate net hunting groups--I followed the larger group. For these exceptions I nevertheless recorded participants' names and captured animals. My data set also includes ten additional hunts from preliminary work before the 12-month period, and eight hunts from forest camps.

For all hunts that I accompanied, I recorded the names of the participants, and the duration of hunting activities. I also roughly mapped the course of the hunt. I weighed and measured captured animals, and recorded the sex, age and reproductive state of all duikers. The fast pace of the hunts and the large number of hunters made it difficult to locate all animals captured, especially when several animals

were killed in one circle of nets.² On at least nine occasions the net hunt group temporarily split into two parts setting up separate circles, then regrouping. Furthermore, the hunt does not stop when animals are killed, and animals are butchered during the day. In some cases, when I did not find the hunter immediately after the animal was killed, or the person carrying the animal, I was unable to measure it. Even when I found the hunter and the animal, I had time for only quick measurements, and when many blue duikers were being captured I only weighed the animals. I also recorded the number of animals by species that were encountered but that escaped.³

Description

Several anthropologists have described net hunting elsewhere in central Africa (Bahuchet, 1985b; Demesse, 1978; Harako, 1976; Ichikawa, 1983; Tanno, 1976). However, practices vary by area and by ethnic group. This section describes net hunting as practiced by the Mossapoula BaAka, including beliefs and rituals associated with net hunting, seasonal variations, and the hunting range.

²As many as six animals were killed in a single circle of nets: one *A. africanus*, one *C. callipygus*, and four *C. monticola*.

³Because I was unable to record the same information for all net hunts and for all animals, the data sets throughout this chapter vary from table to table.

Communal Net Hunting Practice

Table 5.1 provides general descriptive statistics from 81 day hunts from Mossapoula. Net hunting is a communal activity involving people of all ages and both sexes. One woman who regularly hunted, often carrying her own net, was at least 60 years old. Babies are carried along by their mothers. One woman net hunted until one week before she gave birth, and she resumed hunting when her infant was two weeks old. Only children too large to carry but too small to walk stay in Mossapoula. Boys and girls begin to contribute as soon as they can keep up, perhaps as young as five years of age. The number of participants in a net hunt ranges from less than 10 to over 100. Women generally outnumber men, and occasionally a net hunting group comprises only women. The only hunting groups that did not include women were organized for tourists.

Table 5.1: Descriptive Statistics for Mossapoula Net Hunts
(64 primary group hunts, 9 secondary group hunts, and
7 tourist hunts)

Primary group (N=64)

	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>
Participants			
Women (%)	3-61 (5-100)	31.6 (63)	16.15
Men (%)	0-41 (0-76)	18.8 (37)	10.65
Total	5-99	50.4	24.39
Technology			
Nets	4-25	15.3	4.74
Spears	0-13	4.6	3.29
Duration			
Casts	6-28	16.5	4.52
Hours hunting	0.88-6.35	4.11	0.94
Hours out	2.43-9.29	6.59	1.41
Yields			
Captures	0-29	8.5	7.05
Escapes	0-20	7.8	4.70
Kilograms	0.0-188.5	46.0	37.86

	<u>Second group (N=9)</u>		<u>Tourist hunts (N=7)</u>	
	<u>Average</u>	<u>SD (+)</u>	<u>Average</u>	<u>SD (+)</u>
Participants				
Women (%)	8.1 (71)	7.02	3.4 (24)	2.44
Men (%)	3.0 (29)	2.41	11.6 (76)	4.87
Total	11.1	8.83	15.0	5.01
Technology				
Nets	4.7	0.47	--	--
Spears	--	--	--	--
Yields				
Captures	2.9	2.77	2.3	0.88
Escapes	--	--	--	--
Kilograms	14.2	17.05	9.9	3.66

Note: Hours out is total time away from Mossapoula.

Participants do not include infants.

Differences in means between primary group and second group hunts are statistically significant in all cases: $t \geq 9.67$, $p < 0.01$.

Differences in means between day hunts (combined primary and secondary group hunts) and tourist hunts are statistically significant with respect to women participants and total participants ($t \geq 3.05$, $p < 0.01$), and with respect to captures and kilograms of meat ($t \geq 2.08$, $p < 0.025$). The difference in mean number of men participating is not statistically significant: $t = 1.197$.

The number of nets ranges from as few as five to over twenty: too few nets and the enclosed circle will be minuscule, too many and the circle becomes unmanageable. Although a hunting group may have more nets, a circle generally includes no more than twenty. Nets measure 1-1.5 meters in height and 5-40 meters in length, averaging 18.3 meters ($N = 54$, $SD \pm 6.96$). Nets are made from the inner bark of the creeper the BaAka call "kosa" (*Manniophyton fulvum*). However, if available, nylon cord or fishing nets are used, as they are stronger and more durable. Several hunters use nylon cords along the top and bottom of the nets--structurally these are the two most important cords for the net. Another hunter joined a 10 meter length of nylon fishing net with 13 meters of "kosa" net.

Mossapoula hunters form a closed circle of nets around a likely patch of forest where there is thick brush in which animals may be hiding--for example, a treefall gap or rattan tangle. The nets are hung on small trees or vines by means of wooden hooks at each end. The top of the net is then hooked on other vegetation, and the bottom pegged to the ground. There are often small gaps between nets through which animals sometimes escape. If there are many nets, one or two may be set singly inside the main circle of nets. In some cases when an animal is spotted in between casts, hunters will set one or more nets just to trap that

particular animal. Thus it is possible, though rare, to capture animals with a single net.

The hunters communicate by means of high-pitched calls and whistles in moving to a new site, in beginning the circle, in calling for additional nets, and in alerting the others to their progress. Once the circle is complete, the net carriers begin searching the interior, beating leaves and shouting to drive animals from their hiding places. The other participants remain hidden near the nets, on the inside or the outside of the circle, to spot flushed animals, to frighten them into the nets, and then to seize them before they can escape.

The hunters quickly determine that there are no animals inside the circle, or that what was there has been captured or escaped. They then gather up their nets and move on to the next spot, usually only a couple hundred meters away, and begin the cycle once again. The entire cycle of setting up the nets, beating, and moving to the next site takes only 10-15 minutes. Thus a net hunt comprises 4-6 casts per hour, and lasts 3-6 hours, for a total of 10-30 casts in one day. Day hunts may begin just outside Mossapoula, and range as far as two hours' walk or ten kilometers from the village. Net hunts take place on average one hour's walk and 3.75 kilometers ($SD \pm 2.14$) from Mossapoula.

The hunters may return with their nets to the village, or leave them in the forest where the hunt ends, in order to

begin the next hunt from that point. Nets left in the forest are folded and tied to the top of a pole, with a covering of leaves to shed water in case of rain. Hunters take their nets back to Mossapoula to have them available in case tourists come the next day to hunt, or to protect them from rain and pests: ants sometimes nest in them, and rodents eat the cord.

The net hunt is primarily a hunt for the blue duiker (*Cephalophus monticola*), which comprises 75 percent of captures. The three other primary prey species are the brush-tailed porcupine (*Atherurus africanus*), the bay duiker (*C. dorsalis*), and the Peters duiker (*C. callipygus*). Larger animals are rarely encountered,⁴ in part because they are warned away by the noise the net hunting group makes moving through the forest while calling to each other. In any case, large animals including bay and Peters duikers can tear through the nets or jump over them to escape.

Nets are owned by men and women, and both will carry nets during a hunt. Nets are often used by the owner's spouse, by children or other relatives, and sometimes by friends. However, a captured animal is the property of the net owner, even if the owner is not hunting. The owner can

⁴Elephants were encountered ten times, and gorillas four times. These animals and leopards are occasionally encircled by the nets, creating a very dangerous situation for the hunters, as the animal may feel cornered by the people on all sides and attack. The hunters drop everything they are carrying, including clothes, and run.

keep or sell the entire animal if he or she so chooses. In practice, the person who seizes the animal in the net usually receives the head of the animal, and those who help set up and guard the net receive other portions. On roughly ten percent of all hunts, portions of meat were contributed at the end of the hunt by those who had killed animals to be divided up among those who had nothing.

During net hunts many animals are killed with spears: men in the net hunting group always carry at least one spear, and as many as thirteen. Animals killed by spears belong to the person who first spots the animal and calls for a spear; the spear owner and the person who killed the animal usually receive the head or a leg.

One or more hunters also often bring along small porcupine nets, which they set inside the circle of nets or near likely hiding places. These small nets are held open by a stick bent to form an arch and stuck into the ground on porcupine trails. When the animal follows its trail through the arch, it enters the bag and pulls the drawstring closed on itself. However, during the net hunts I accompanied no porcupines were captured in this manner.

Animals caught in nets are usually clubbed to death with the nearest heavy stick, though porcupines are dispatched with a machete. Small animals such as blue duikers and porcupines are then dropped into a basket and carried by a woman until she has time to butcher them.

Large animals such as bay and Peters duikers are usually butchered at the spot where they are killed.

The net hunt is as much a gathering event as it is a hunting event. Whether or not animals are killed, the participants all return with something: "payo" (*Irvingia excelsa*) and other nuts, caterpillars, mushrooms, "koko" leaves (*Gnetum buchholzianum*), fruit, wild yams (*Dioscorea* spp.), honey, "kosa" (*Manniophyton fulvum*) bark strips for making cord and nets, "ngongo" (*Megaphrynium macrostachyum*) leaves for wrapping food or roofing huts, rattan (*Eremospatha* sp. and *Ancistrophyllum secundiflorum*), etc.⁵ These products are eaten or used by the hunters themselves, or they are sold.

Net hunts are not planned in advance. Hunts can take place on any day, if the weather is conducive, if an interested group with nets is not otherwise occupied, and if a "leader" catalyzes the group into action. One man who called himself the "chief of the net hunt" led 25 net hunts from Mossapoula and from forest camps. But 25 other individuals, three of them women, also led hunts (Figure 5.1).⁶

⁵See Appendix 8 for a list of commonly collected types of nuts, mushrooms, caterpillars, and honey.

⁶However, two of the women only led for part of the hunt before a man arrived and replaced them.

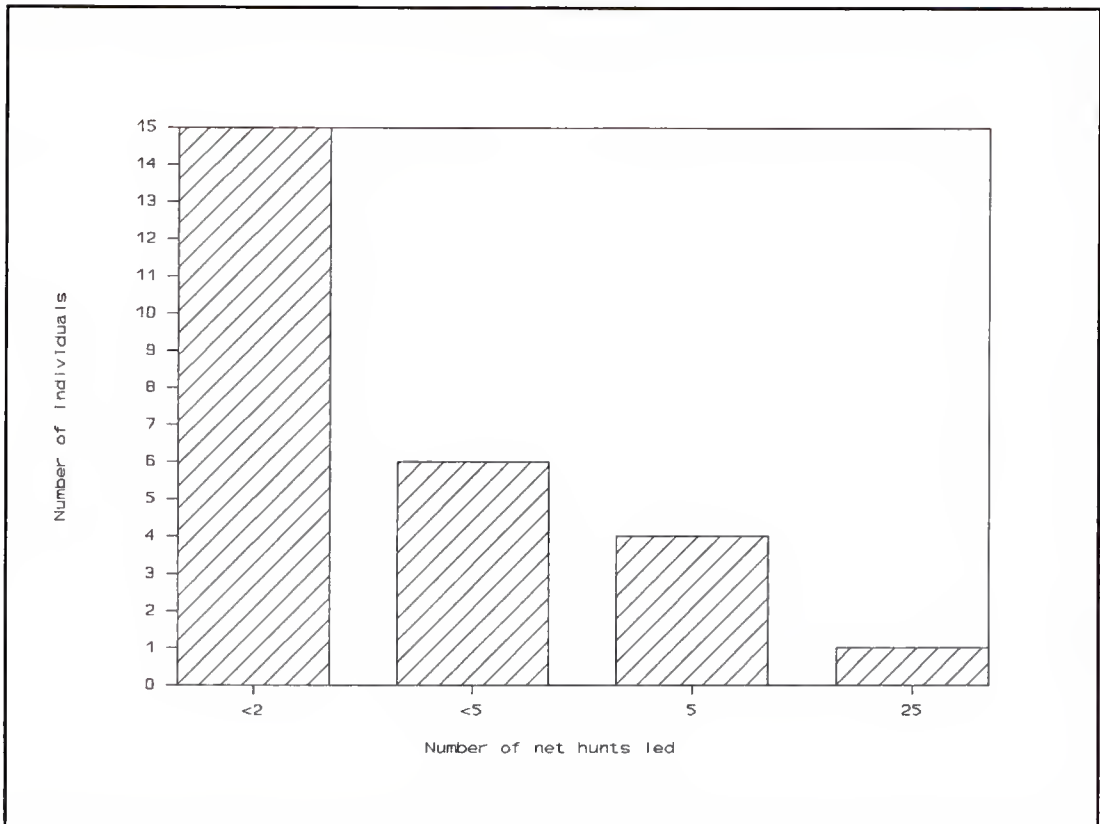


Figure 5.1: Net Hunt Leaders

The "leader", always a man unless only women are hunting, is one of the first to leave Mossapoula. He chooses the starting point for that day's hunt, or returns to the place where the nets were left after the previous hunt. Hunters leave Mossapoula in pairs or small groups, following the leader's trail. The first arrivals rest at the starting point until a sufficiently large group has collected--they say they are waiting for the women to arrive.

Once the hunt begins, the leader may determine the general direction of the hunt, and may identify likely

places to set the nets. But other individuals may also call for nets when they find promising patches of forest. Usually there are no breaks during the hunt, though occasionally the leader will call for a rest break in the middle of the day, or early in the hunt to discuss who is responsible if the hunt is beginning unsuccessfully. The leader also generally determines when the hunt will end, and where the nets will be left. But individuals drop in and out of the group throughout the hunt. They may fall behind while butchering animals or collecting other items, and miss a couple casts before rejoining the group. They may also leave Mossapoula late and join the hunt in progress. Or they may quit early to return to Mossapoula, to check snares, or to collect other products.

Beliefs and Rituals

Little ritual is attached to net hunts from Mossapoula.⁷ Occasionally, before the hunt, hunters rub leaves and spit on their nets while imitating the cry that duikers make when captured in order that their net will kill "meat". In two instances hunters cut off an animal's leg while it was still caught in the net, saying their net had not killed for a long time and it needed the blood for good

⁷BaAka rituals and religious organization were traditionally centered on collective spear hunting, which is no longer practiced in Mossapoula (Bahuchet, 1985b; Kisliuk, 1993).

luck. Before hunters take down nets that they have left in the forest overnight, they make a loud popping sound by clapping one hand down on a leaf placed over their other fist.

More involved rituals are practiced in forest camps. On one occasion the camp leader rose before dawn, and from the edge of camp called out the names of the animals, while the other camp members echoed him from their huts. Before the hunt started that day the leader took each net, rubbed leaves and spit on it, while again calling the names of the animals. Another group in a forest camp conducted a small dance before beginning a hunt, following one hunter holding a hoop decorated with leaves as he danced around imitating the calls of the hunt.

In December 1994, the week before I left, Mossapoula began a "jengi" dance, which also brings good luck to net hunters. The "jengi" is a forest spirit in a large raffia mask (Bahuchet, 1985b; Hewlett, 1977; 1991; Joiris, 1993; Kretsinger, 1995). Only men may touch him, and they form a protective circle between the jengi and the dancing women. As the jengi moves forward, the women fall back, and as he retreats, the women follow, all the while circling the drummers. The jengi periodically runs off into the forest and then returns, and the dance can last all night and into

the next day. He may or may not appear every night, for several weeks or as long as a year.⁸

Poor success in net hunting is almost always attributed to sexual reasons. On at least seven occasions, after several fruitless casts to begin the hunt, the group paused to discuss who was responsible for the bad luck. They eventually identified one or more individuals--men who had slept with their wives the previous day, or whose wives were pregnant, or women in the early stages of pregnancy. These individuals then remained behind the group for one or two casts, and rejoined the group when something was captured.

A person's death is also a reason for poor hunting success. Upon hearing of a Bilo death in Mossapoula, the members of a forest camp cited that as the cause for their recent bad luck. A BaAka death brings everyone from forest camps back to Mossapoula and suspends hunting from Mossapoula for several days as well. A forest camp where someone dies is also abandoned, and hunters avoid areas where people are buried.

Poor hunting was also blamed on one particular individual who often led net hunts: residents of the same forest camp described above said he was jealous of them and

⁸One jengi dance in Monassao lasted over a year before it was stopped by one of the missionaries. She drove her car into the dance, stopped by the jengi and ordered him to get in. Then she drove him out of town and told him to go back to the forest because people could not work if they were dancing all night long.

gave them bad luck. Later, when he formed his own forest camp, the people remaining in Mossapoula said he had taken the hunting luck with him.

On a few occasions unsuccessful casts towards the end of the hunt were blamed on fatigue or lack of interest among the participants, and the hunt usually disintegrated soon afterward. Hunters never attribute poor hunting to overhunting in areas near Mossapoula, by themselves or by Bilo competitors, and laugh at the idea that in the future there might be no animals in the forest if they hunt too much today--"there will always be animals", they say.

Seasonality

Mossapoula residents net hunt continuously throughout the year. However, at certain times of the year fewer hunts take place because many people are otherwise occupied (Table 5.2). I recorded two weeks with only a single hunt, one a tourist hunt, and a maximum of eight net hunts during a five day period. On average, I recorded 3.6 net hunts (excluding tourist hunts) during a five day period ($SD \pm 1.69$), or 5.0 per week. Including tourist hunts the average increases slightly to 4.0 ($SD \pm 1.86$), or 5.6 per week.

Table 5.2: Reasons Cited for not Net Hunting
(for 32 days when no hunts took place)

Rain	12
Collect caterpillars	7
Collect mushrooms	6
Collect honey	5
Fishing	4
To Bayanga	4
Collect "payo" nuts	3
Tired	3
Tourist hunts	3
Funeral	2
Holiday	2

Note: On several occasions, more than one reason was given the same day.

Because most nets are made of natural fibers which deteriorate more quickly if they are wet, and because wet nets are heavier to carry, net hunting is not practiced during or immediately following rain. In addition, it is very difficult to hear and see flushed animals in the rain, and animals are reluctant to move. The chances of running into elephants also increase, because the rain drowns out other sounds. Net hunts often do not start until 9 or 10 a.m. because hunters are waiting for the forest to dry out after the previous day's rain or the night's dew. Rain only cut short four net hunts that I observed. But rain the day before or the threat of rain that day was cited as a cause on twelve days when net hunts did not take place.

Net hunting from Mossapoula is more frequent during the December-February dry season: 6.1 hunts per week, versus 4.6 hunts per week in the rainy season. However, the difference in means is not statistically significant:

t = 1.17. Rain is not the sole cause for this difference. Even in the wet season, rain falls only every second or third day, and more often in the afternoon. Thus it is possible to hunt even on days when it rains. But the wet season is when some people, including the most enthusiastic net hunters, move to forest camps, and thus do not mobilize hunts in Mossapoula.

In addition, during the wet season people are diverted from net hunting by periodic and temporary profusions of other forest foods--they prefer to gather caterpillars or mushrooms to eat or sell. In March, and again in October, when the large "muséle" mushrooms were appearing in abundance in the forest, many people went to gather mushrooms rather than hunt. One net hunt that did take place disintegrated after several unsuccessful casts, and the participants dispersed to seek mushrooms.

In late August and early September a mass outbreak of several species of caterpillars diverted people's interest from net hunting. Caterpillars fall to the ground in large quantities when they are ready to pupate, and people collect the caterpillars and pupae to eat. Compared to other forest areas in CAR with an annual "caterpillar season", caterpillar outbreaks are relatively small and irregular in the Bayanga region, perhaps because the logging company harvests important caterpillar trees--in particular *Entandrophragma cylindricum* and *Triplochiton scleroxylon*

(Bahuchet, 1979a; 1985b). Caterpillars have been abundant in the past two years, after several very poor years.

There is no pronounced "honey season" when most people move to forest camps and focus on honey collection rather than hunting. People seek hives and harvest honey throughout the year, exploiting more than 10 types of honey. Honey is harvested occasionally by individuals on day trips from Mossapoula, and small amounts of honey from stingless bees are collected by members of net hunting groups during hunts. More attention is devoted to honey collection in forest camps, and all of the instances when honey harvesting superseded hunting were from forest camps. On two of the days when forest camps did net hunt, the hunts were interrupted for several hours in order to collect honey.

Other reasons for not hunting have nothing to do with seasons. After several days of hard hunting, people will take a rest day. Many people prefer to come into Bayanga on holidays, as well as on Sundays. Or a scarcity of manioc may induce people to work in their fields, or to walk to Bayanga to work for Bilos in exchange for manioc.

Mossapoula Net Hunting Range

The hunting range (Figure 5.2) for Mossapoula net hunters is limited to the west by the Sangha river, an impassable barrier for people without canoes. To the north, the Gbabongo river forms a rough boundary running east to

west through Gbabongo, especially as the Bilo and BaAka inhabitants of Gbabongo hunt in that area. Mossapoula hunters say they have hunted north of the Gbabongo river upon occasion, in company with Gbabongo BaAka. They also hunt to the northwest of Gbabongo along logging roads when tourists take them by vehicle. To the south, they do not cross the Kenie river that runs east to west through Bayanga. The BaAka living in Bayanga hunt along the Kenie, and south of the Kenie is the hunting range of the Yandoumbé BaAka. To the east, the Dzanga sector of the National Park, including its pre-park buffer zone two kilometers wide, officially prohibits hunting more than eight kilometers from Mossapoula. In practice, the Park boundary is rarely crossed because it is at the edge of the range accessible to day hunters from Mossapoula, two hours' walk away.⁹

⁹In February, 1989, the Mossapoula and Yandoumbé BaAka reported that they could no longer hunt within 10 kilometers of settlements because of declines in wildlife populations (Wilson and Wilson, 1989). In fact, most hunting by Mossapoula residents takes place on day trips within 10 kilometers of Mossapoula. Areas further away are only accessible from forest camps, or if tourists provide transportation.

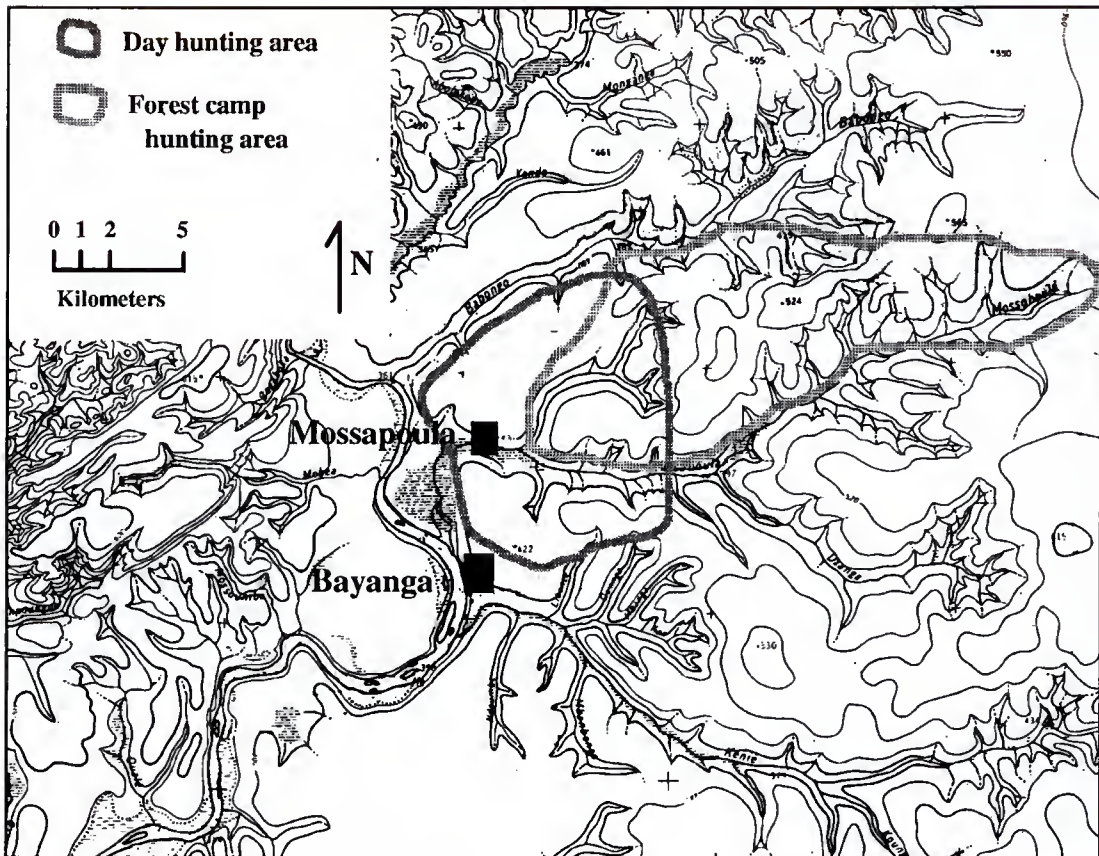


Figure 5.2: Mossapoula Net Hunting Range

While the Mossapoula population has continuously increased, its hunting range has steadily declined as a result of the demarcation of international boundaries, logging activity, the creation of national parks, and competition with other hunters (Figure 5.3).

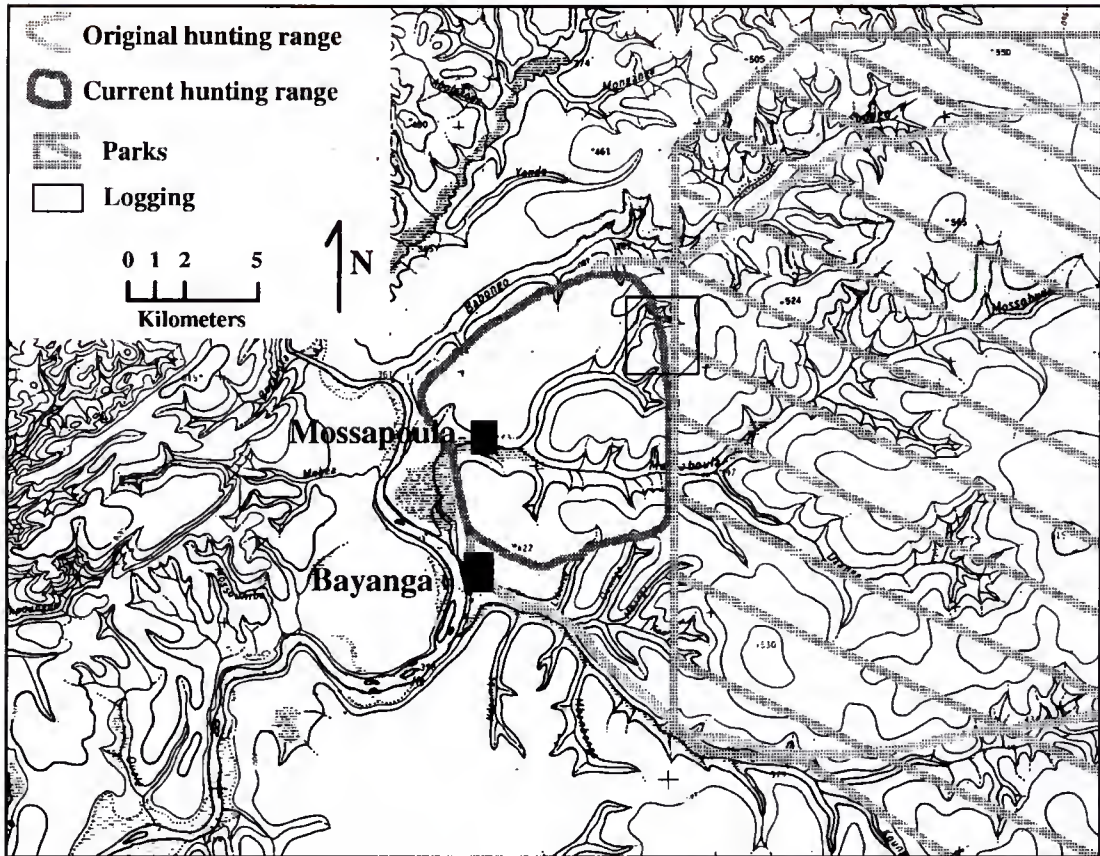


Figure 5.3: Mossapoula Hunting Range Decline

International borders officially prohibit population migrations between CAR and Congo, though the original Mossapoula BaAka came from Congo several decades ago, and more may recently have ranged into Congo to hunt from forest camps. Virtually all of the Mossapoula hunting range, from the Sangha river in the west to the Congo border in the east, was logged between 1971 and 1980. Logging operations disturbed both wildlife populations and hunting activities, though the area of disturbance where trees were being cut and removed shifted over time. The Dzanga-Ndoki Park in CAR

and the Ndoki-Nouabale Park in Congo now entirely occupy the original range for forest hunting camps for the Mossapoula BaAka. Snare and gun hunters from Bayanga and Gbabongo, as these population centers grow, increasingly hunt in the same area that the Mossapoula hunters exploit.

The current hunting range exploited by Mossapoula residents is about 110 square kilometers, or approximately 2.7 persons per square kilometer. Within this range, net hunters never set nets in marsh or swamp forest, where the vegetation is too thick. They also generally avoid monodominant forest, where the undergrowth is too sparse and offers no hiding places for animals. Therefore net hunters exploit mixed upland forest, with undergrowth that is sufficiently thin to permit movement and visibility, yet with patches of thick brush where animals can hide.

Table 5.3 describes the distribution of hunting pressure by net hunters on day trips from Mossapoula and from forest camps in 1994. All day hunts, and 30 percent of forest camp hunts, take place within 10 kilometers of Mossapoula. The most intensely exploited area lies within five kilometers of town. Forest camps therefore exploit areas within the day hunting range where net hunting pressure is lower, and they also increase the hunting range for Mossapoula residents.

Table 5.3: Net Hunting Pressure within Mossapoula Hunting Range (hunts/km²/year)

	<u>Day hunts</u>			<u>Forest camps</u>			<u>Total</u>		
	<u>N</u>	<u>%</u>	<u>P</u>	<u>N</u>	<u>%</u>	<u>P</u>	<u>N</u>	<u>%</u>	<u>P</u>
0-5 kms (55 km ²)	166	65	3.0	0	0	0.0	166	50	3.0
5-10 kms (50 km ²)	89	35	1.8	23	28	0.5	112	33	2.3
>10 kms (30 km ²)	0	0	0.0	58	72	1.9	58	17	1.9
Total	255	100		81	100		336	100	

Notes: N = number of hunts per year.

P = hunts/km²/year.

Extrapolations for day hunts are from 63 recorded hunts during 90 observation days in 1993-1994. Forest camps data are based on 13 observation days in 2 separate camps, extrapolating for 20 weeks of forest camping in 1993-1994.

Impacts of Net Hunting on Wildlife

This section examines the impacts of net hunting on wildlife populations in the Bayanga region with respect to the species distribution, age structure, and sex ratios of captured animals. As in the preceding chapter, an attempt is made to assess the sustainability of hunting offtakes by Mossapoula net hunters.

For the three most commonly captured duiker species (*Cephalophus callipygus*, *C. dorsalis*, and *C. monticola*), I recorded the following biological information for each individual captured: sex, weight, body measurements, reproductive state (pregnant or lactating), and age (number of erupted molars). For all other species I only recorded sex, weight, and body measurements. In addition to the animals captured, I also recorded all instances of animals that were seen but escaped.

Captures

During 76 observed net hunts (on day trips and from forest camps) 589 animals were captured, representing nine species: six mammals, one bird, and two reptiles (Table 5.4). The principal prey of net hunters is the blue duiker *Cephalophus monticola*, which represents 74.6 percent of captures. The three other primary prey species, in order of importance, are the brush-tailed porcupine *Atherurus africanus* (11.9 percent), the bay duiker *C. dorsalis* (6.8 percent), and the Peters duiker *C. callipygus* (4.1 percent). Other species comprise less than three percent of net hunt captures. Because they are 3-4 times larger than *C. monticola*, *C. dorsalis* and *C. callipygus* together represent 30 percent of returns by weight, though less than 11 percent of captures. On other hunts I saw guinea fowl (*Guttera* spp. or *Agelastes niger*) captured in nets, and one Gaboon viper (*Bitis gabonica*) was encountered and killed. Hunters spoke too of catching the other duiker species, bush pigs, and monkeys upon occasion. But, in general, only relatively small terrestrial animals are vulnerable to nets (see Appendix 4).

Though net hunters do not hesitate to kill protected species, they are rarely encountered or captured: I only recorded one captured water chevrotain (*Hyemoschus aquaticus*). Although it is probably abundant in the Bayanga region, net hunters tend to avoid the swampy and riverine

forest habitat that this species and fully protected black-fronted duiker *C. nigrifrons* prefer. With respect to large protected animals such as chimpanzees, elephants, gorillas or leopards, the noise of an approaching net hunting group usually warns them to move away.

Table 5.4: Net Hunt Captures
(number of animals and kilograms by species)

	<u>N</u>	<u>Percent</u>	<u>Average</u> <u>Weight</u>	<u>Total</u> <u>Weight</u>	<u>Percent</u>
<i>C. monticola</i> *	440	74.6	4.53	1,993.20	61.8
<i>A. africanus</i>	70	11.9	3.20	224.00	6.9
<i>C. dorsalis</i> *	40	6.8	16.32	652.80	20.2
<i>C. callipygus</i> *	24	4.1	12.70	304.80	9.4
<i>Kinixys erosa</i>	10	1.7	2.13	21.25	0.7
<i>Francoolinus</i> sp.	2	0.3	0.25	0.50	..
<i>Herpestes naso</i> *	1	0.2	3.00	3.00	0.1
<i>Hyemoschus aquaticus</i> **	1	0.2	13.50	13.50	0.4
<i>Python sebae</i> *	1	0.2	14.25	14.25	0.4
All species	589	100.0	5.05	3,227.30	100.0

Notes: Data are from 76 observed net hunts. *partially protected species. **fully protected species.

During a net hunt 88.4 percent of captures are made with nets (Table 5.5). An additional 10.1 percent of animals are captured with spears, most notably half the *C. dorsalis* captures, and 21 percent of *A. africanus* captures. A chi-square test on net versus spear captures for the four primary game species suggests that differences by species and by method are statistically significant: chi-square = 88.11, $p < 0.01$. Because *C. dorsalis* is nocturnal, it is frequently discovered sleeping or resting where it can be approached and speared. *A. africanus* too is nocturnal, and

can be speared when it is flushed from its hiding place. Animals are also occasionally killed by machete. The most dramatic kill was a 3 meter, 15 kilogram python. Finally, animals like tortoises and young duikers are caught by hand.

Table 5.5: Net Hunt Captures by Method
(number of animals and percent by species)

	<u>Net</u>		<u>Spear</u>		<u>Machete</u>		<u>Hand</u>	
	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
<i>C. monticola</i>	414	94.1	21	4.8	0	0.0	5	1.1
<i>A. africanus</i>	54	77.2	15	21.4	1	1.4	0	0.0
<i>C. dorsalis</i>	20	50.0	19	47.5	0	0.0	1	2.5
<i>C. callipygus</i>	22	91.7	2	8.3	0	0.0	0	0.0
<i>Kinixys erosa</i>	0	0.0	0	0.0	0	0.0	10	100.0
<i>Francolinus</i> sp.	2	100.0	0	0.0	0	0.0	0	0.0
<i>Herpestes naso</i>	0	0.0	0	0.0	1	100.0	0	0.0
<i>H. aquaticus</i>	0	0.0	1	100.0	0	0.0	0	0.0
<i>Python sebae</i>	0	0.0	0	0.0	1	100.0	0	0.0
Total	512	86.9	58	9.9	3	0.5	16	2.4

Note: Data are from 76 observed net hunts.

On average, eight animals are captured during every hunt, or roughly one animal for every two casts of the nets (Table 5.6). Six *C. monticola* are captured per hunt, or one for every 2.7 casts. Six hunts captured no animals at all. The single most successful hunt captured 29 animals: 23 *C. monticola*, three *C. dorsalis*, two *C. callipygus*, and one *A. africanus*.

Table 5.6: Net Hunt Capture Rate

	<u>Range</u>	<u>Animals/hunt</u>		<u>Casts/animal</u>
		<u>Average</u>	<u>SD (+)</u>	
<i>C. monticola</i>	0-24	5.8	5.60	2.64
<i>A. africanus</i>	0-6	0.9	1.25	15.61
<i>C. dorsalis</i>	0-3	0.5	0.71	29.16
<i>C. callipygus</i>	0-3	0.3	0.67	46.17
Other	0-3	0.2	0.58	69.25
All species	0-29	7.8	6.78	1.95

Note: Data on captures per hunt are from 79 recorded hunts. Data on casts per animal are from 68 observed hunts.

Age Structure and Sex Ratios

No captured animal is ever released. Very young duikers tend to lie motionless when danger threatens. Many are missed by net hunters, but a few are captured by hand or in nets (Table 5.7). Those missed include the young of one *C. dorsalis* and seven *C. monticola* females that were lactating--these young probably did not survive. Numerous unborn fetuses are also killed in pregnant females captured.¹⁰ As with snare hunting, net hunters predominantly capture adult animals. The age structure for *C. monticola* differs significantly from that reported by Dubost (1980) in Table 3.3 (chi-square = 46.20, $p < 0.01$), suggesting that net hunting captures are biased toward adult blue duikers.

¹⁰According to Vivian Wilson, female duikers conceive within days of parturition, and are therefore pregnant virtually all the time.

Table 5.7: Age Structure of Net Hunt Captures
(number of individuals by age class)

	<u>Fetuses</u>	<u>Number of molars</u>			<u>Subadult</u>	<u>Adult</u>
		<u><1</u>	<u><2</u>	<u><3</u>		
<i>C. monticola</i>	56	1	8	28	71	303
<i>A. africanus</i>	--	--	--	--	18	50
<i>C. dorsalis</i>	6	1	2	3	5	29
<i>C. callipygus</i>	1	0	4	5	3	10

Notes: I did not dissect uteri, and therefore only recorded fetuses large enough to detect by touch. Actual pregnancy rates may have been considerably higher.

Subadult and adult duikers all have complete dentition (3 molars): animals were classified as subadults if their reproductive organs were not fully developed, or if they were considerably below average adult weights.

Female duikers are captured more frequently than males for all three duiker species (Table 5.8). Assuming a 1:1 sex ratio, the selective bias by net hunting toward female duikers is statistically significant: chi-square = 11.82, $p < 0.01$. However, it is possible that adult females are more numerous than adult males, perhaps because males are more vulnerable to natural causes of mortality. Alternatively, males may be less vulnerable to net hunters because they are more mobile, whereas females may be more reluctant to leave their home ranges. Females that are pregnant or lactating may also be more vulnerable than males. Of the female duikers, 25 percent of *C. dorsalis* and 27 percent of *C. monticola* were pregnant or lactating. On the contrary, net hunters capture female *A. africanus* only half as often as males. *A. africanus* is nocturnal and hides in burrows or hollow logs in the daytime--those captured are flushed from

their hiding places. Females may be less inclined to run, and stay in their holes.

Table 5.8: Sex Ratios of Net Hunt Captures
(number of individuals, female/male ratio)

	<u>Female</u>	<u>Male</u>	<u>Ratio</u>
<i>C. monticola</i>	234	187	1.3
<i>C. dorsalis</i>	28	12	2.3
<i>A. africanus</i>	23	45	0.5
<i>C. callipygus</i>	13	11	1.2

Vulnerability

The species most often captured, *C. monticola*, is also the one most often encountered and the most vulnerable mammal:¹¹ 68 percent of all encounters are *C. monticola*, and 59 percent of *C. monticola* encountered are captured (Table 5.9 and Figure 5.4). This species is particularly vulnerable because of its small size: unlike the larger duikers, it can rarely rip through or jump over a net. And unlike a porcupine, a blue duiker can be seized by hand when entangled in a net. *C. monticola* is the most frequently encountered game species because it is the most abundant of the duikers, and stays within a small home range rather than moving away from approaching hunters. Net hunters therefore encircle and search brush patches where blue duikers tend to conceal themselves.

¹¹All the tortoises and the single python encountered were captured.

Table 5.9: Vulnerability to Net Hunting by Species

<u>Species</u>	<u>Encounters</u>	<u>Captures</u>	<u>Percent Captured</u>
<i>C. monticola</i>	747	440	58.9
<i>A. africanus</i>	180	70	38.9
<i>C. dorsalis</i>	90	40	44.4
<i>C. callipygus</i>	61	24	39.3
<i>Kinixys erosa</i>	10	10	100.0
<i>Loxodonta africana</i>	10	0	0.0
<i>Herpestes naso</i>	8	1	12.5
<i>Genetta spp.</i>	7	0	0.0
<i>Cricetomys emini</i>	4	0	0.0
<i>Gorilla gorilla</i>	4	0	0.0
<i>Hyemoschus aquaticus</i>	3	1	33.3
<i>Neotragus batesi</i>	2	0	0.0
<i>C. sylvicultor</i>	1	0	0.0
<i>Mellivora capensis</i>	1	0	0.0
<i>Python sebae</i>	1	1	100.0
<i>Varanus niloticus</i>	1	0	0.0
All species	1,116	587	52.6

Note: I did not count escaped francolins or guinea fowl, and therefore cannot calculate vulnerability for these species.

C. dorsalis is also relatively vulnerable to net hunting, particularly when the hunters carry spears. *C. dorsalis* is encountered more frequently than *C. callipygus*, though the latter is probably more abundant. In turn, 44 percent of *C. dorsalis* encountered are captured, compared to 39 percent of *C. callipygus*. *C. dorsalis* is nocturnal and is reluctant to move in the daytime, whereas *C. callipygus* is diurnal and is more likely to move away from approaching hunters.

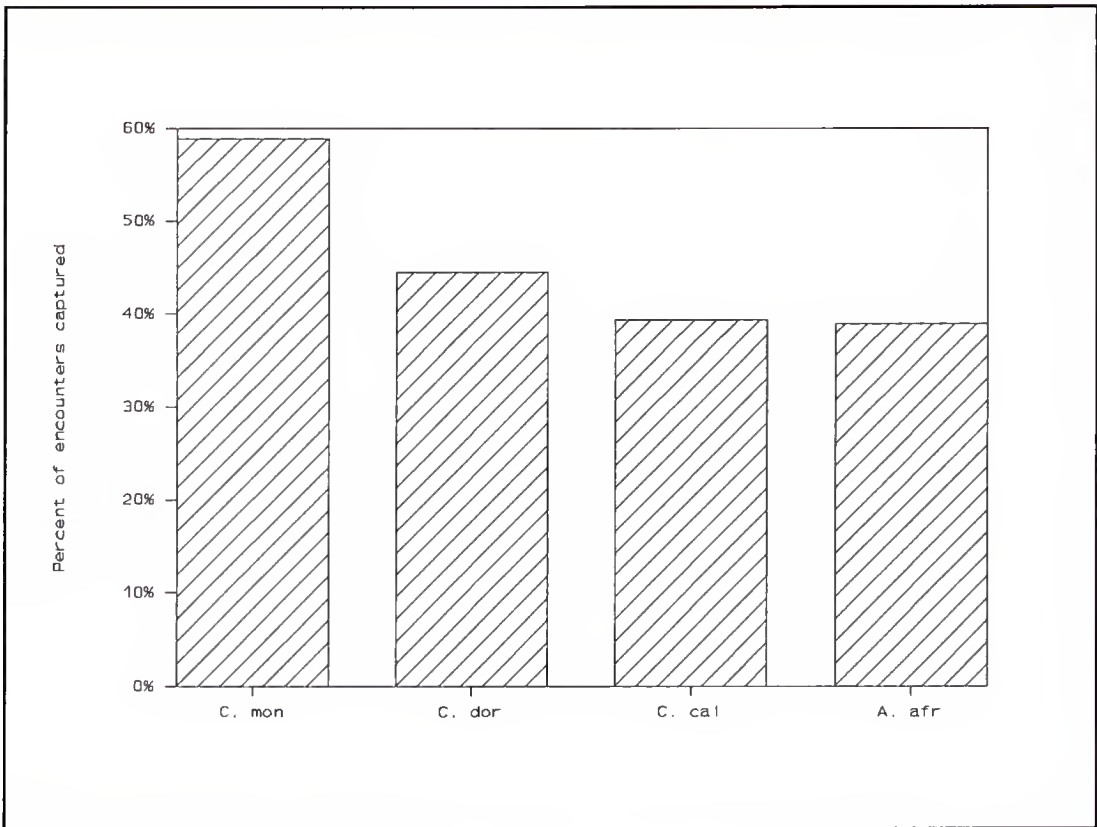


Figure 5.4: Species Vulnerability to Net Hunters: *C. monticola* (N=747 encounters), *A. africanus* (N=180), *C. dorsalis* (N=90) and *C. callipygus* (N=61)

Notes: Differences in vulnerability among the four primary game species are statistically significant: $G = 10.56$, $p < 0.02$. In comparing only the three duikers, differences in vulnerability are ambiguous: $G = 4.47$, $p < 0.2$.

A. africanus can be difficult for net hunters to capture because not everyone carries a machete or spear, and hunters cannot seize the animal by hand as they do with duikers entangled in nets, giving it more time to fight its way free. Therefore, although porcupines are smaller than *C. monticola*, they are less vulnerable to net hunters.

Net hunting wastes very little, though occasionally an animal wounded by a spear will escape: four *C. monticola* versus 440 captures and four *C. dorsalis* versus 40 captures. In this respect too, *C. dorsalis* is particularly vulnerable to net hunting, raising to 49 percent the proportion of *C. dorsalis* encounters that are captured or injured. Dogs rarely accompany net hunters from Mossapoula,¹² who say that the dogs flush animals before the nets are ready. Therefore wounded animals are rarely tracked, though on two occasions wounded bay duikers were followed for several hundred yards and captured.

Sustainability of Net Hunting Harvest

Conservationists often assume that subsistence hunting by indigenous peoples using traditional technologies is sustainable. As discussed in Chapter 3, estimating population densities and sustainable harvest rates remains problematic throughout tropical forests, as models and methods depend on theories and assumptions that may not be consistent with particular field conditions. Wildlife populations fluctuate over time in response to environmental conditions and hunting pressure. Net hunting patterns also vary according to the economic opportunities available to Mossapoula residents, which influence in particular the

¹²Only two or three Mossapoula residents own dogs, and they brought their dogs along on a total of eight net hunts. One dog was carried by its owner part of the time.

importance of forest camps, and of day hunting.

Nevertheless, the sustainability of net hunting harvests is important both from a conservation perspective and a development perspective. The following discussion uses the available data to address the question of whether or not Mossapoula net hunting harvests are sustainable.

Despite continuous hunting pressure within the Mossapoula net hunting range, net hunters regularly encounter and capture the four primary prey species. Annual harvest rates within this area are based on extrapolations from recorded captures during 90 observation days of hunts from Mossapoula, including all primary and secondary group hunts (Table 5.10). An estimated 23 forest camp hunts occurring within the day hunting range are included in the calculations. But hunts for tourists are excluded because they generally occur outside the 110 km² day hunting range. Net hunting offtakes of all four game species lie within the very wide range of estimated sustainable levels: hunting is sustainable under the least conservative conditions, and unsustainable under the most conservative conditions.

Table 5.10: Mossapoula Annual Net Hunt Harvest Rates
(individuals per square kilometer by species)

<u>Species</u>	<u>SH</u>	<u>D</u>	<u>SH*</u>
<i>A. africanus</i>	9.9-67.5	2.7-17.6	0.27-11.88
<i>C. monticola</i>	2.3-34.4	10.5-66.9	0.24-23.01
<i>C. dorsalis</i>	1.6-21.3	0.3-6.6	0.01-1.13
<i>C. callipygus</i>	1.2-21.8	0.9-3.7	0.01-0.81

<u>Species</u>	<u>Day hunt harvest rate</u>	<u>Forest camp harvest rate</u>
<i>A. africanus</i>	2.3	0.7
<i>C. monticola</i>	14.6	2.4
<i>C. dorsalis</i>	1.2	0.5
<i>C. callipygus</i>	0.8	0.2

Notes: See Appendix 3 for calculations of sustainable harvest rates.

SH is the range of sustainable harvest rates predicted in theory, as a percentage of the population.

D is the range of estimated population densities in the Bayanga region according to line transect surveys and net hunt encounters (see Chapter 3).

SH* is the number of individuals per square kilometer that may be sustainably harvested, given SH and D.

The day hunting area is 110 km². The total number of hunts per year within this area include 215 primary group hunts, 41 secondary group hunts and 23 forest camp hunts.

The forest camp hunting area in 1993-1994 was 30 km², and 58 hunts from forest camps occurred within this area.

Harvest rate is the number of individuals harvested per square kilometer by net hunters each year.

Table 5.11 presents the sustainability indices for net hunt harvests from day hunts and from forest camps. Day hunters from Mossapoula probably overexploit all three duiker species. In addition, *C. monticola* and *C. dorsalis* are also the most vulnerable mammals to net hunters, and the two species with the highest proportion of female captures. Therefore *C. dorsalis* is more at risk from net hunting than is *C. callipygus*. The lowest population density estimates, and the lowest sustainable harvest levels, are for areas

within 5 kilometers of Mossapoula, where net hunting pressure is highest.

Table 5.11: Sustainability Index by Species
for Net Hunt Harvests

	<u>Day hunts</u>	<u>Forest camps</u>
<i>C. monticola</i>	0.958	0.417
<i>C. callipygus</i>	0.979	0.729
<i>A. africanus</i>	0.667	0.222
<i>C. dorsalis</i>	0.979	0.896

Notes: See Appendix 3 for the matrix of sustainable harvest levels in the Bayanga region, according to line transect survey and net hunt encounter density estimates, and to theoretical sustainable harvest rates.

The index of sustainability is equal to the number of cell values in the matrix less than or equal to the actual harvest divided by the total number of cells for each species. The higher the index, the more likely that hunting is unsustainable.

Compared to day hunts, hunting from forest camps is more likely to be sustainable for all game species, though *C. dorsalis* and *C. callipygus* may be at risk even in the area exploited only by forest camps. According to the most conservative estimates of population densities and sustainable harvest rates, even these harvests are excessive. Forest camping reflects traditional resource use patterns whereby relatively small groups extensively exploited relatively large areas. Current day hunting patterns result from relatively large permanent settlements intensively exploiting a relatively small area.

Total biomass harvested by net hunters each year on day hunts from Mossapoula exceeds 11,500 kilograms, with duikers comprising 92 percent of the total (Table 5.12). Assuming

300 Mossapoula residents, annual offtake is roughly 38 kilograms for person. Including hunting from forest camps, total biomass harvested each year by Mossapoula residents approaches 13,500 kilograms. Forest camps are located anywhere from 3-25 kilometers from Mossapoula: I have estimated that 30 percent of the hunting from forest camps occurred inside the 110 km² day hunting range, and the other 70 percent outside this range. Therefore, Mossapoula net hunters harvest approximately 105 kilograms per square kilometer within the day hunting range, but less than 65 kilograms per square kilometer in the range exclusively exploited by forest camps.

Table 5.12: Annual Biomass Harvest
by Mossapoula Net Hunters
(number of animals and kilograms)

<u>Species</u>	<u>Average weight</u>	<u>Day hunts</u>		<u>Forest camps</u>	
		<u>Number</u>	<u>Biomass</u>	<u>Number</u>	<u>Biomass</u>
<i>C. monticola</i>	4.53	1,600.81	7,251.67	181.25	821.06
<i>A. africanus</i>	3.20	255.73	818.34	50.75	162.40
<i>C. dorsalis</i>	16.32	136.83	2,233.07	36.25	591.60
<i>C. callipygus</i>	12.70	85.51	1,085.98	14.50	184.15
Other	2.77	50.95	141.13	58.00	160.66
Total		2,254.88	11,530.19	340.75	1,919.87

Notes: Annual harvest from day hunts is based on 90 observation days. Annual harvest from forest camps is based on 13 observation days, extrapolating for 20 weeks of forest camps in 1994.

Potential per capita meat consumption is estimated according to the following assumptions: 60 percent of biomass harvested is edible meat, no meat is sold outside of Mossapoula, and Mossapoula's population numbers

approximately 300 inhabitants. Total production of edible meat from day hunts suggests an annual per capita consumption level of 23 kilograms. If hunting from forest camps is included, per capita meat consumption rises to 27 kilograms per year. However, data suggest that roughly 20 percent of meat from day hunts and 75 percent of meat from forest camps is sold. Actual per capita consumption is 18 kilograms per year from day hunts, and 19 kilograms per year including harvests from forest camps.

In practice, no animal that could be caught is ever ignored, and no animal that is caught is ever released. But unlike snare hunters, net hunters can target particular species or even particular individuals of game species. All animals are seen and identified before they are killed, and many of the duikers are captured in nets alive. Net hunters can therefore manage net hunting offtakes: they can spare protected species, as well as females and young individuals of game species. Fully protected species are seldom killed anyway (one in over 500 captures), and this restriction would not affect hunting yields. Releasing young animals that lack complete adult dentition would also not greatly reduce yields, except in the case of *C. callipygus* (Table 5.13). However, releasing female animals would significantly reduce yields of all four game species, particularly in the case of *C. dorsalis*. Releasing only

pregnant and lactating females would still significantly reduce yields for *C. dorsalis* and *C. monticola*.

Table 5.13: Effects on Net Hunting Yields of Releasing Young, Female, or Pregnant/Lactating Animals (percent reduction in number of animals and kilograms)

	<u>Young</u>		<u>Female</u>		<u>Pregnant</u>	
	<u>N</u>	<u>kg</u>	<u>N</u>	<u>kg</u>	<u>N</u>	<u>kg</u>
<i>C. monticola</i>	9	4	56	59	15	19
<i>A. africanus</i>	0	0	34	33	--	--
<i>C. dorsalis</i>	15	7	70	67	15	20
<i>C. callipygus</i>	41	26	54	51	4	7

Mossapoula net hunters will adopt such management practices that reduce yields only under duress, and enforcement would be difficult. Furthermore, selective harvesting that focuses on particular age groups, or on males only, may not be ecologically sound. In the case of monogamous species like duikers, the population does not include surplus males (Eltringham, 1984). Selective harvesting can disrupt territorial structures, artificially select for inferior males, and result in insufficient males to inseminate all females (Ginsberg and Milner-Gulland, 1994). Therefore, harvest methods such as nets (and snares) that are non-selective by sex better reflect prey availability.

Economic Importance of Net Hunting

This section examines the importance of net hunting for the BaAka today, according to the amount of time devoted to net hunting relative to other economic and subsistence

activities, and according to the returns net hunting produces for Mossapoula residents. In Mossapoula I collected two types of relevant data: 1) time allocation to hunting, and 2) returns from hunting in kilograms and CFA francs. In addition, I have analyzed these data for several levels: the individual, the household, and the community. I define households as people who live together in a house, thus parents and small children. Adolescents over 12 years old may have their own houses, or share houses with other adolescents. Households therefore have from 1-12 members, and average 3.49. Five men each have two wives, and in these cases the husband is counted as a household member of two different households.

Time Allocation to Net Hunting

Based on my census of 320 Mossapoula residents, and on a health survey by Anna Kretsinger and Babon Victor, I compiled a list of all men and women in Mossapoula, adults and adolescents.¹³ The final list is a sample of 126 women and girls, and 113 men and boys, whose activities I tracked for 90 observation from December 1993 to November 1994: 19,656 total person days. In analyzing individual activity

¹³Collecting names is not straightforward, as many individuals have several names, periodically change their names, or take on a good friend's name, while several individuals may share the same name. Most BaAka refer to each other by a single name, although many now have second, "Christian" names.

patterns I use a sub-sample of 113 women and girls and 99 men and boys whose activities I tracked for at least 60 days.

During week-long observation periods, I recorded the principal daily activity for each individual, according to what I saw him or her doing, or according to what my assistant Matofi Fernand and other informants said he or she were doing. The most accurate information is for net hunts, because I accompanied the group and recorded names along the way. As I walked to and from Mossapoula I also met individuals on their way to or from work in Bayanga that day. For everyone else I asked my assistant--often he asked others nearby in cases when he was uncertain. Activities are categorized in the following fashion: net hunt, formal labor, day labor, forest camp, and absent from Mossapoula. An additional catch-all category includes other activities in or near Mossapoula: field work, child care, fishing, gathering, tapping raffia wine, and making raffia roof shingles.

Formal labor includes employment with researchers like myself,¹⁴ with a World Bank forestry survey team, and with a film-maker. Only the film-maker employed women. The project hires several men to work at the tourist center in Bayanga and guide tourists. The logging company hires only

¹⁴Three wildlife researchers in camps outside of Bayanga regularly employed Mossapoula residents in 1993-1994.

men, but when logging operations shifted south of Lindjombo in 1994, a number of Mossapoula families moved to a camp near the work site.

Day labor includes work in Bayanga, Gbabongo, or Mossapoula: women most often work in manioc fields or coffee plantations, while men may clear fields and cut palm nuts, raffia leaves, rattan, or construction poles. Gun hunting and work in the diamond fields are also classified as day labor. During the observation period four different men were hired to hunt with a Bayanga resident's gun. Only one individual, a Bilo man married to a BaAka woman and living in Mossapoula, spent any significant time in the diamond fields. Other men and women made only short visits.

Table 5.14 presents individual activity patterns: how individuals occupy themselves over time. Table 5.15 presents community activity patterns: how the community occupies itself each day. The pattern of mean values for individual activities is virtually identical to the pattern for community activities.

Table 5.14: Mossapoula Individual Activity Distribution
(percent of days per individual)

<u>WOMEN (N=113)</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>	<u>Average days/year</u>
Mossapoula	5.6-100.0	45.5	19.0	166
Net hunt	0.0-43.3	18.1	11.0	66
Day labor	0.0-33.3	11.3	7.6	41
Formal labor	0.0-44.4	5.5	11.9	20
Forest camp	0.0-20.0	3.2	5.4	12
Absent	0.0-94.4	14.4	23.4	53
<u>MEN (N=99)</u>				
Mossapoula	1.1-95.6	40.2	22.4	147
Formal labor	0.0-93.3	24.2	22.0	88
Net hunt	0.0-32.2	11.6	8.7	42
Day labor	0.0-66.7	7.0	10.1	26
Forest camp	0.0-20.0	3.2	5.0	12
Absent	0.0-94.4	11.6	23.4	42

Notes: N = 90 observation days. Total days per year are less than 365 days because not all individuals were on my list for the full 90 day observation period.

Differences in means between women and men are statistically significant for the following categories: Mossapoula ($t = 1.84$, $p < 0.1$), net hunt ($t = 4.73$, $p < 0.01$), day labor ($t = 3.50$, $p < 0.01$), and formal labor ($t = -7.82$, $p < 0.01$). Differences in means for forest camps ($t = 0.04$) and absent ($t = 0.86$) are not significant.

Net hunts took place on 58 of the 90 observation days, corresponding to an estimated 235 net hunt days per year, and 130 days when there are no hunts at all. However, only a portion of the community hunts on each net hunt day, and the group of net hunters varies in size and composition from day to day: the proportion of the community participating when hunts occur ranges from 2.5-39.7 percent (average 21.2 percent, $SD \pm 10.1$). Figure 5.5 presents community participation rates in net hunting.

Table 5.15: Mossapoula Community Activity Distribution
(percent of persons per day)

<u>WOMEN (N=126)</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>	<u>Average persons/day</u>
Mossapoula	14.3-75.4	42.5	15.8	54
Net hunt	0.0-46.0	16.7	16.0	21
Day labor	0.0-42.9	10.9	9.8	14
Formal labor	0.0-16.7	5.3	6.0	7
Forest camp	0.0-19.8	3.1	4.4	4
Absent	4.0-23.8	13.3	5.4	17
<u>MEN (N=113)</u>				
Mossapoula	16.4-59.5	37.8	10.4	43
Net hunt	0.0-35.3	10.4	10.6	12
Day labor	3.4-16.4	10.4	3.4	12
Formal labor	0.0-25.9	6.2	4.5	7
Forest camp	0.0-19.8	2.9	4.3	3
Absent	11.2-32.8	20.9	4.9	24

Notes: N = 90 observation days. Total persons per day are less than 126 and 113 respectively because not all individuals were on my list for the full 90 day observation period.

Differences in means between women and men are statistically significant for the following categories: Mossapoula ($t = 2.36$, $p < 0.05$), net hunt ($t = 3.13$, $p < 0.01$), formal labor ($t = -19.10$, $p < 0.01$), day labor ($t = 4.09$, $p < 0.01$) and absent ($t = 4.33$, $p < 0.01$). Differences in means are not significant only in the case of forest camp ($t = 0.37$).

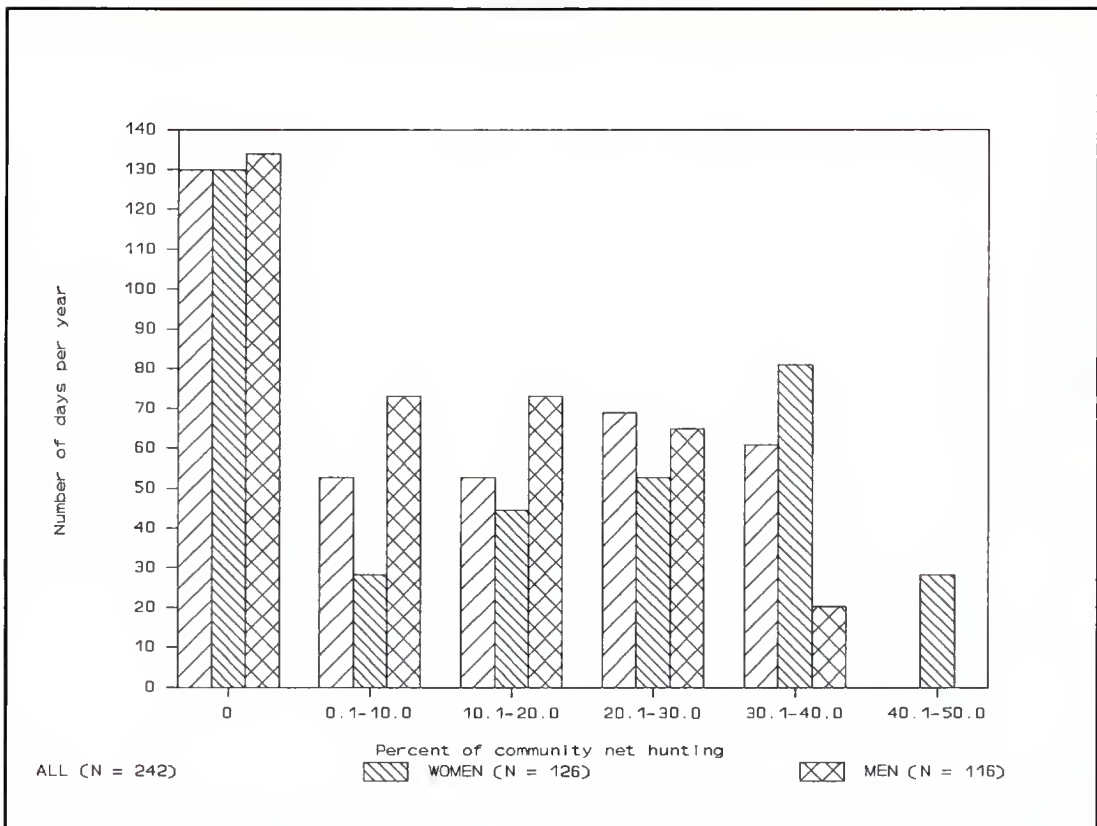


Figure 5.5: Community Participation in Net Hunting

Notes: Extrapolations from 90 observation days. Differences between women and men are statistically significant: $t = 3.129$, $p < 0.01$.

The most enthusiastic net hunters only participate in 67.2 percent of net hunts. On average, individuals hunt on only 23.7 percent of hunts that take place ($SD \pm 16.44$). But 92.4 percent of Mossapoula residents participated in at least one net hunt during the research period. Figure 5.6 presents individual participation rates in net hunting, and Figure 5.7 shows the number of days individuals devote to net hunting during the year. On average, every resident of

Mossapoula spends only 55 days per year net hunting (range 0-158, SD $\pm$ 39).

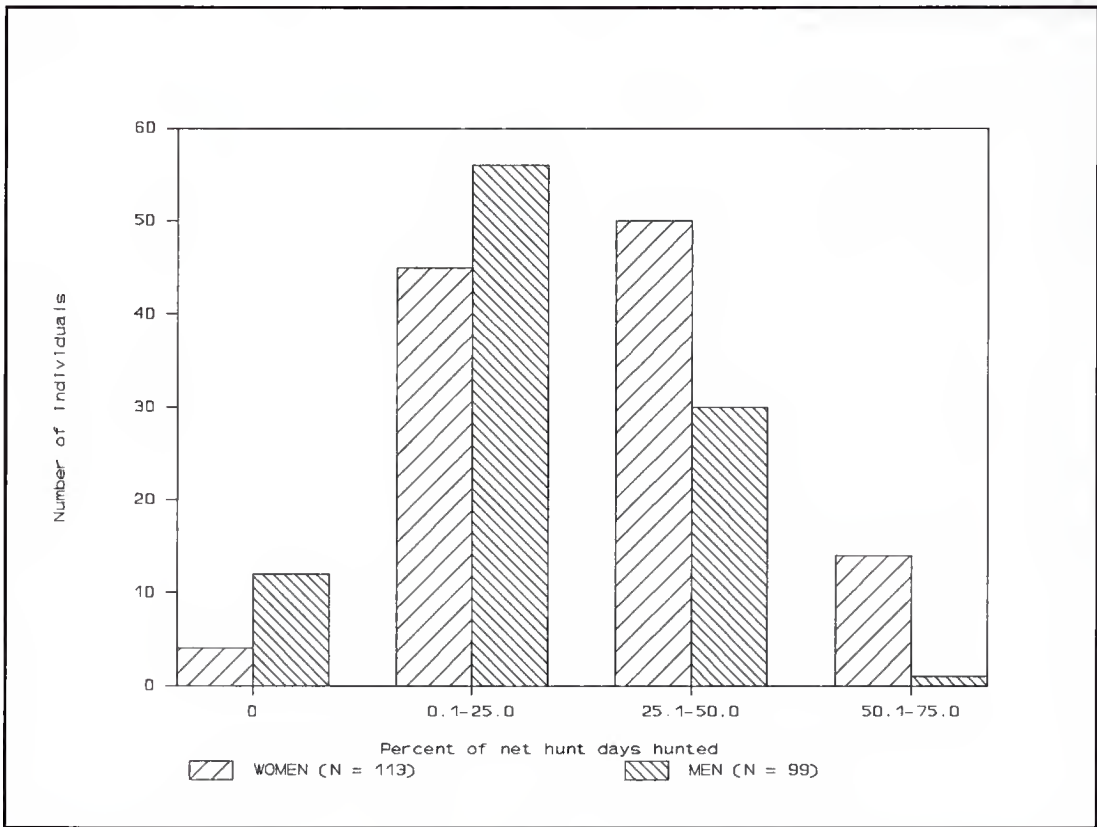


Figure 5.6: Individual Participation in Net Hunting

Note: Extrapolations from 90 observation days. Differences between women and men are statistically significant: $t = 4.65$, $p < 0.01$.

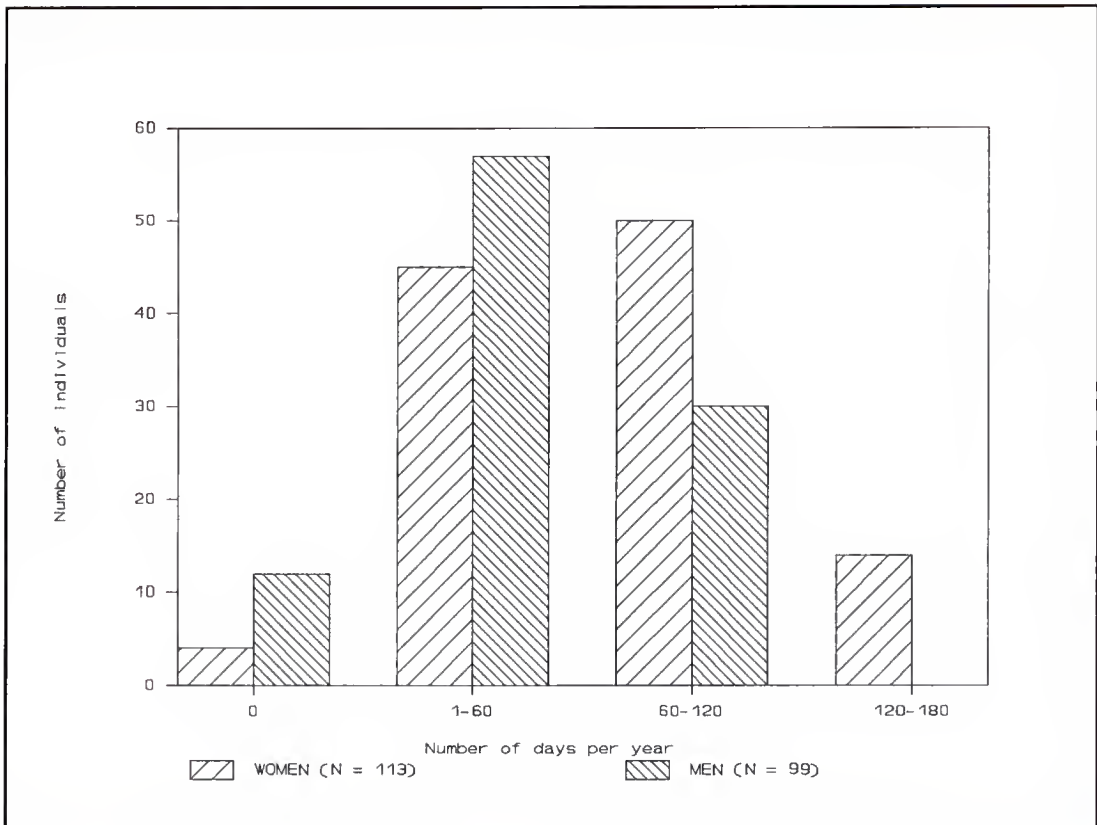


Figure 5.7: Time Allocation to Net Hunting

Note: Extrapolations from 90 observation days. Differences between women and men are not statistically significant: $t = 0.042$.

Activity patterns vary by age group (Table 5.16).¹⁵ In all age groups, women are more likely to participate in net hunts than are men (Figure 5.8), and allocate more time to net hunting than do men (Figure 5.9). The most active hunters are women 15-20 years old, and men 20-25 years old. Although individuals of all age groups net hunt, participation rates are relatively low for the youngest and

¹⁵Information on estimated ages of Mossapoula residents was provided by Anna Kretsinger.

the oldest age groups. Several adults are physically unable to hunt because of age or disabilities, although one person is described as "too lazy", and one prefers other work. Many adolescents prefer alternatives to net hunting, such as work in Bayanga or fishing: since they do not own nets they are more likely to obtain food from activities other than net hunting. These adolescents do learn hunting skills by moving to forest camps with their families, and through "games" such as group spear hunts for rats in the village.

Table 5.16: Activity Distribution by Age Group
(percent of days per individual, age in years)

<u>WOMEN (N = 126)</u>	<u><15</u>	<u>15-20</u>	<u>20-25</u>	<u>25-35</u>	<u>35-45</u>	<u>>45</u>
Mossapoula	44.3	44.1	38.3	48.8	47.0	55.2
Net hunt	13.2	22.8	19.1	19.7	18.3	15.4
Day labor	10.7	12.2	12.8	13.9	10.2	4.4
Formal labor	4.8	11.2	4.6	3.9	6.5	0.6
Forest camp	2.8	1.3	2.7	2.9	5.3	4.4
Absent	15.9	7.7	22.4	11.2	11.6	19.4
<u>MEN (N = 116)</u>	<u><15</u>	<u>15-20</u>	<u>20-25</u>	<u>25-35</u>	<u>35-45</u>	<u>>45</u>
Mossapoula	65.8	27.8	28.9	32.4	42.1	47.8
Net hunt	9.2	13.0	16.0	12.5	10.4	4.0
Day labor	6.3	8.0	4.6	9.1	6.6	3.8
Formal labor	7.6	32.1	30.6	27.5	25.2	22.7
Forest camp	2.9	1.3	2.4	3.9	5.5	0.2
Absent	2.1	14.7	17.3	13.0	10.2	21.6
<u>TOTAL (N = 242)</u>	<u><15</u>	<u>15-20</u>	<u>20-25</u>	<u>25-35</u>	<u>35-45</u>	<u>>45</u>
Mossapoula	54.0	35.5	34.6	40.2	44.7	52.5
Net hunt	11.4	17.6	17.9	16.0	14.6	11.3
Day labor	8.7	10.0	9.6	11.3	8.5	4.2
Formal labor	6.2	22.2	14.9	16.2	15.2	8.5
Forest camp	2.8	1.3	2.6	3.5	5.4	2.9
Absent	9.7	11.4	20.4	12.1	11.0	20.2

Note: Extrapolations based on 90 observation days.

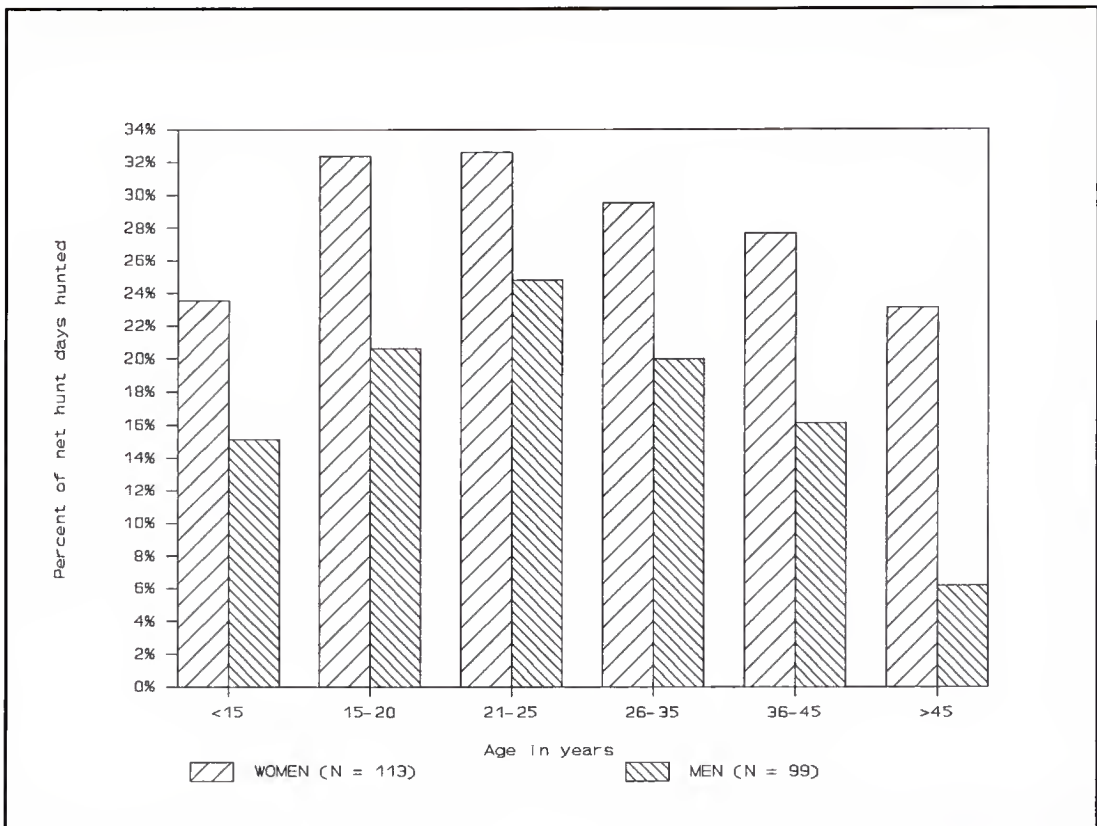


Figure 5.8: Net Hunt Participation Rates by Age Group

Note: Differences between women and men are not statistically significant: $\chi^2 = 4.39$, $p < 0.5$.

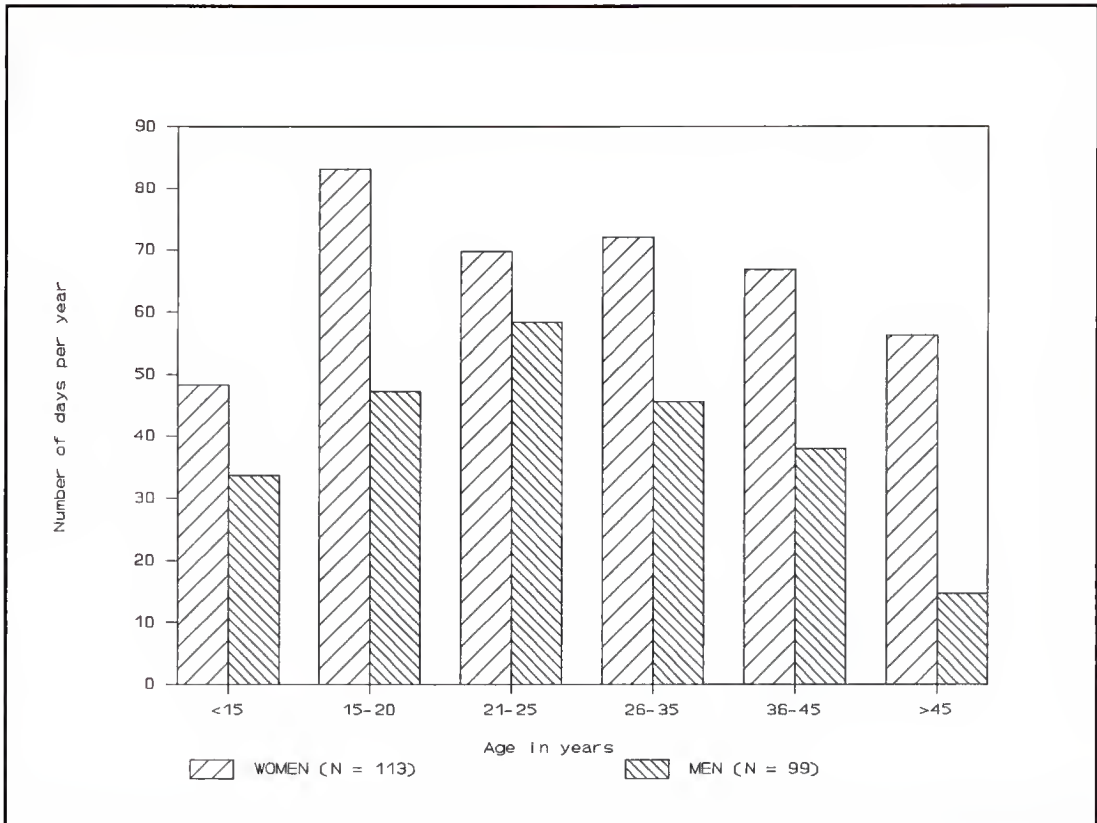


Figure 5.9: Time Allocation to Net Hunting by Age Group

Note: Differences between women and men are statistically significant: chi-square = 12.89, $p < 0.05$.

Despite the low participation rates at the individual level, net hunting represents the single most important activity for which I have data. Over time, individuals switch intermittently among available activities. New opportunities do not entirely replace net hunting: virtually all individuals continue to practice net hunting at least occasionally and maintain the skills in their repertoire. Should the alternative opportunities evaporate, individuals may participate more in net hunting.

In practice, most of the formal employment is not long-term employment. The project and the logging company hire Mossapoula residents as temporaries, on a daily or weekly basis. Work for Bayanga residents is also on a daily basis. Only the researchers have longer-term arrangements with employees from Mossapoula, hiring them full-time for several weeks or months, or on a rotating schedule of 2-3 weeks on, 2-3 weeks off. Therefore, individuals drop in and out of the formal employment system, engaging in hunting activities in between intermittent formal employment.

Returns from Net Hunting

This section examines the returns from net hunting in order to assess the importance of wildlife as an economic and subsistence resource. For every hunt that I accompanied, I weighed all animals captured immediately after they were killed. This was usually the only time I saw the animal, as the hunting action continued and the animal would be butchered and distributed later during the hunt. Of the total carcass weight approximately 60 percent is edible, excluding stomach contents, bones and hooves (Ichikawa, 1983; Martin, 1985; Tanno, 1976). For animals that I was unable to measure I estimated weights based on averages for the species.

Mossapoula residents rarely sell meat directly to consumers in Bayanga, perhaps because it is more convenient

to sell to the Bayanga merchants who bring goods for sale to Mossapoula every evening. Prices paid in Mossapoula are generally lower than those in Bayanga, because Bayanga merchants want to make a profit reselling the meat in Bayanga, and often pay a lower value of manioc or other goods rather than cash.¹⁶ To estimate the value of meat production from net hunting, I use the following prices: 1,000 CFA for *A. africanus*, 3,000 CFA for *C. callipygus* and *C. dorsalis*, and 1,000 CFA for *C. monticola*. As in Bayanga, prices fluctuated after devaluation, and in 1993 were considerably below these estimates.

I was unable to determine accurately how much meat was consumed in Mossapoula versus how much was sold. Because the meat is butchered and distributed during the hunt, parts of each animal are spread among several individuals who return separately to Mossapoula. People wishing to buy meat visit Mossapoula in the evening after the net hunters have returned, going from house to house to inquire what and how much is for sale.¹⁷ Particularly with large duikers, a leg or two may be sold, while the rest is eaten. The proportion sold obviously depends on how much individual hunters captured, but also on their need for cash or goods. Some

¹⁶The Bayanga women merchants also say that the net hunters cut smaller portions than the snare hunters, for example removing the ribs from the *C. monticola* half.

¹⁷Mossapoula women complain that the Bayanga women are extremely aggressive, entering their huts and taking meat that is being cooked for dinner off the fire.

meat is sold to other BaAka in Mossapoula. I have therefore calculated only totals: total kilograms were everything eaten in Mossapoula, and total CFA were everything sold.

Table 5.17 provides data on average returns per hunt from 73 day hunts from Mossapoula. Of these hunts, five captured no animals at all. The average returns per hunter in CFA francs equal the minimum logging company wage of 200 CFA per day, but are well below the official minimum wages of 650 CFA per day that can be earned from other formal employment. In addition, net hunts do not take place every day, and Mossapoula residents can maximize their income by pursuing formal employment. However, formal employment opportunities are limited, and apply exclusively to men. Net hunting continues to be practiced because it provides an income earning and subsistence opportunity for other Mossapoula residents, and supplies products in addition to meat.

Table 5.17: Net Hunt Returns

<u>Day hunts (N=73)</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>
Total kg	0.0-188.5	42.0	37.53
Edible kg	0.0-113.1	25.2	22.52
g/hunter	0.0-1,866.7	549.5	588.72
g/resident	0.0-353.4	80.6	70.43
g/prot/res	0.0-53.0	12.1	10.56
cal/res	0.0-636.1	145.1	126.78
Total CFA	0.0-38,500	8,904	7919.65
CFA/hunter	0.0-1,500	202.8	197.12
<u>Tourist hunts (N=7)</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>
Total kg	4.5-16.5	9.9	3.66
Edible kg	2.7-9.9	5.9	2.20
g/hunter	207.7-825.0	423.6	194.24
g/resident	9.3-30.9	21.3	6.38
g/prot/res	1.4-4.6	3.2	0.96
cal/res	16.7-55.6	38.3	11.48
Total CFA	6,000-9,000	7,285	880.63
CFA/hunter	308-750	526.4	147.05

Notes: Returns in kilograms and calories assume everything is consumed in Mossapoula, whereas returns in CFA assume everything is sold. The two sets of measures are therefore mutually exclusive.¹⁸

"Edible meat" is estimated to be 60 percent of the carcass weight (Ichikawa, 1983; Martin, 1985; Tanno, 1976). 100 g of edible meat contain approximately 180 calories (Bailey and Auger, 1989; Bailey and Peacock, 1988), and 15 g of protein (Dwyer, 1985; Martin and Ruberte, 1978).

Returns per resident are calculated for 300 Mossapoula residents.

Differences between mean values for day hunts and tourist hunts are statistically significant for all variables ($t \geq 2.214$, $p < 0.025$) except in the case of grams per hunter ($t = 0.56$).

¹⁸The project's export/market survey (see Chapter 3) reported an average of 2.4 pieces of meat purchased by Bayanga market women in Mossapoula each day. Given an average daily meat production by net hunting in Mossapoula of 12.1 pieces, the data suggest that 20 percent of net hunting returns are sold, and the remaining 80 percent consumed in Mossapoula. Average returns per hunter then include 440 grams of edible meat and 41 CFA per hunt.

Data for seven hunts undertaken for tourists are also provided for comparative purposes. Because tourists pay a 5,000 CFA fee that is shared among a relatively small group, hunters earn on average 526.4 CFA, or two and a half times what they earn on day hunts. And they are guaranteed to earn something, whereas hunting alone is not so reliable. In fact, the minimum income per hunter from tourist hunts exceeds the average income from day hunts. Tourists generally take hunters to areas outside the Mossapoula hunting range, which are hunted less frequently. Therefore, average returns per hunter in meat also approach those for day hunts, although the tourist hunts are much shorter: 1-2 hours, versus over 6.5 hours for day hunts. With many fewer participants, averaging 15 versus over 50 for day hunts, tourist hunts guarantee a higher proportion of the catch to hunters: 7.3 percent (range 3.9-10.0 percent, $SD \pm 1.84$) compared to 4.2 percent (range 1.0-20.0 percent, $SD \pm 4.44$) of the catch for day hunt participants ($t = -5.377$, $p < 0.01$). At the community level, the production of meat from tourist hunts is low, but the income is roughly equivalent to the average income obtained from day hunts because of the 5,000 CFA fee paid by the tourists.

Net hunts do not take place every day, and on some days more than one group may hunt. Table 5.18 aggregates the data for 20 five-day observation periods, for the community

as a whole. Each period includes on average 3.6 hunts (range 0-7, SD $\pm$ 1.68), and 164 person/days (range 0-358, SD $\pm$ 101.12) devoted to net hunting, again excluding tourist hunts.

Table 5.18: Mossapoula Weekly Net Hunt Returns
(N=20 5-day observation periods, day hunts only)

	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>
Total kg	0.0-421.0	151.15	116.12
Edible kg	0.0-252.6	90.69	90.69
kg/hunter	0.00-3.85	1.90	1.16
g/resident	0.0-789.4	290.4	215.3
g/prot/res	0.0-118.4	43.6	32.3
cal/hunter	0.0-6,924.1	3,424.1	2085.8
cal/res	0.0-1,420.9	522.6	387.6
Total CFA	0-89,000	32,050	24,706.1
CFA/hunter	0-1,355	667	402.0

Notes: Returns in kilograms and calories assume everything is consumed in Mossapoula, whereas returns in CFA assume everything is sold. The two sets of measures are therefore mutually exclusive.

"Edible meat" is estimated to be 60 percent of the carcass weight (Ichikawa, 1983; Martin, 1985; Tanno, 1976). 100 grams of edible meat contain approximately 180 calories (Bailey and Aunger, 1989; Bailey and Peacock, 1988), and 15 grams of protein (Dwyer, 1985; Martin and Ruberte, 1978).

Returns per resident are calculated for 300 Mossapoula residents.

Meat is generally distributed within families, and to those who help the net owner set up and guard the net during the hunt. Therefore, usually only those people who participate in the hunt have access to the meat, although some additional sharing takes place when the hunters return to Mossapoula, and when the meat is cooked. But every resident of Mossapoula does not receive meat.

Nor does everyone who participates in a hunt receive meat, even if animals are killed. And among those hunters who do capture animals, some are more skillful, or more lucky, or have longer nets than others. Table 5.19 and Figures 5.10 and 5.11 present annual returns from net hunting, with captures attributed solely to the person carrying the net or spear which captured the animal.

Table 5.19: Annual Net Hunting Returns
(kilograms and CFA francs)

		<u>All residents</u>		<u>Active hunters</u>	
<u>Kilograms</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>	<u>Average</u>	<u>SD (+)</u>
Women	0.0-121.1	15.3	26.3	15.8	26.6
Men	0.0-294.4	47.3	58.7	53.8	59.8
Households	0.0-415.5	55.4	68.9	58.9	69.6
		<u>All residents</u>		<u>Active hunters</u>	
<u>CFA francs</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>	<u>Average</u>	<u>SD (+)</u>
Women	0-44,611	5,562	9,430	5,768	9,541
Men	0-101,389	17,656	21,464	20,091	21,802
Households	0-146,000	20,439	25,041	21,751	25,274
		<u>Successful hunters</u>			
<u>Kilograms</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>		
Women	1.83-121.1	38.0	29.3		
Men	7.91-294.4	72.0	58.9		
Households	2.43-415.5	78.3	70.1		
		<u>Successful hunters</u>			
<u>CFA francs</u>	<u>Range</u>	<u>Average</u>	<u>SD (+)</u>		
Women	811-44,611	13,843	10,330		
Men	4,056-101,389	26,891	21,292		
Households	811-146,000	28,213	21,802		

Notes: N = 112 total women, of whom 108 were hunters, and 45 were successful hunters. N = 99 men, of whom 87 hunted, and 65 were successful. N = 116 households, 109 that hunted, and 82 that were successful.

Differences between women and men, and between individuals and households, are statistically significant: $|t| \geq 2.97$, $p < 0.01$.

Of the 195 individuals who hunted during the 90 day observation period, 43.6 percent captured nothing at all.

The estimated annual returns for the most proficient hunter were 294.43 kg of edible meat, and 101,389 CFA. With respect to households, only 25.7 percent captured nothing, while maximum returns were 415.49 kg and 146,000 CFA.

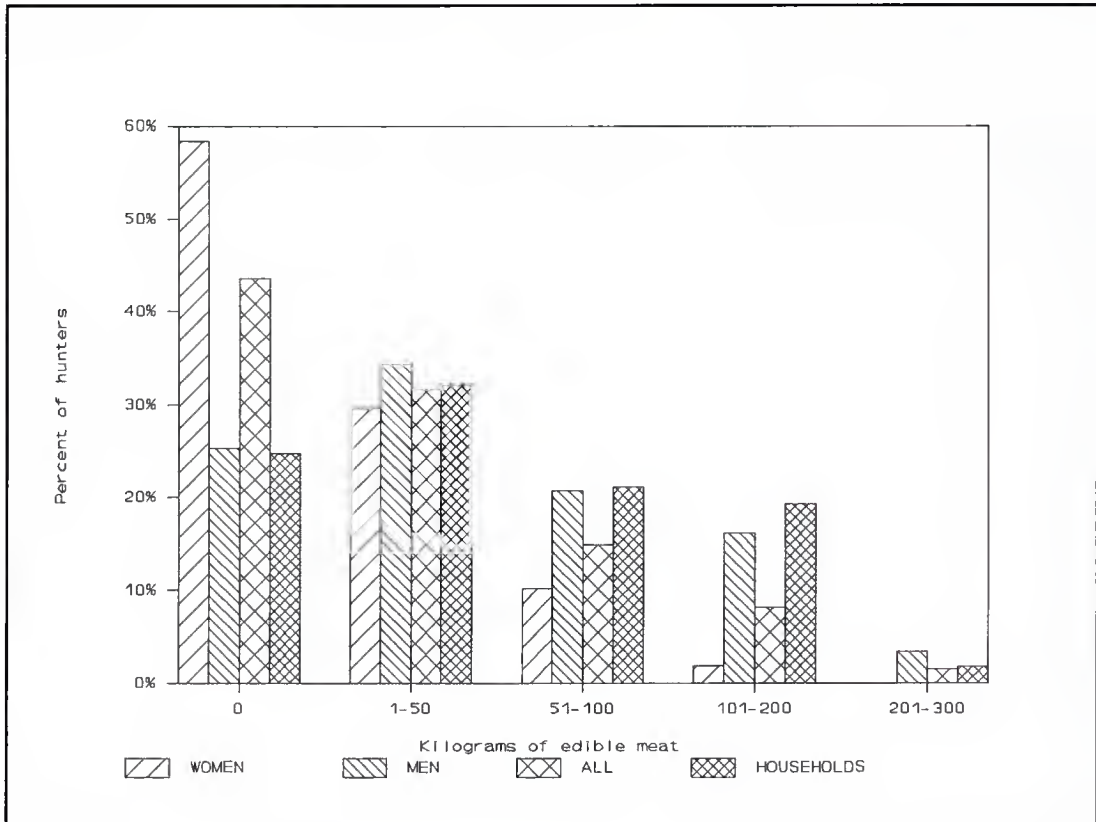


Figure 5.10: Annual Returns from Net Hunting (kilograms)

Notes: One outlying value is excluded: a household with estimated annual returns of 415 kilograms.

Captures are attributed solely to the person carrying the net or spear which killed the animal. Returns assume that all meat is consumed in Mossapoula.

Differences between women and men, and between individuals and households, are not statistically significant: $|t| \geq 2.97$, $p < 0.01$.

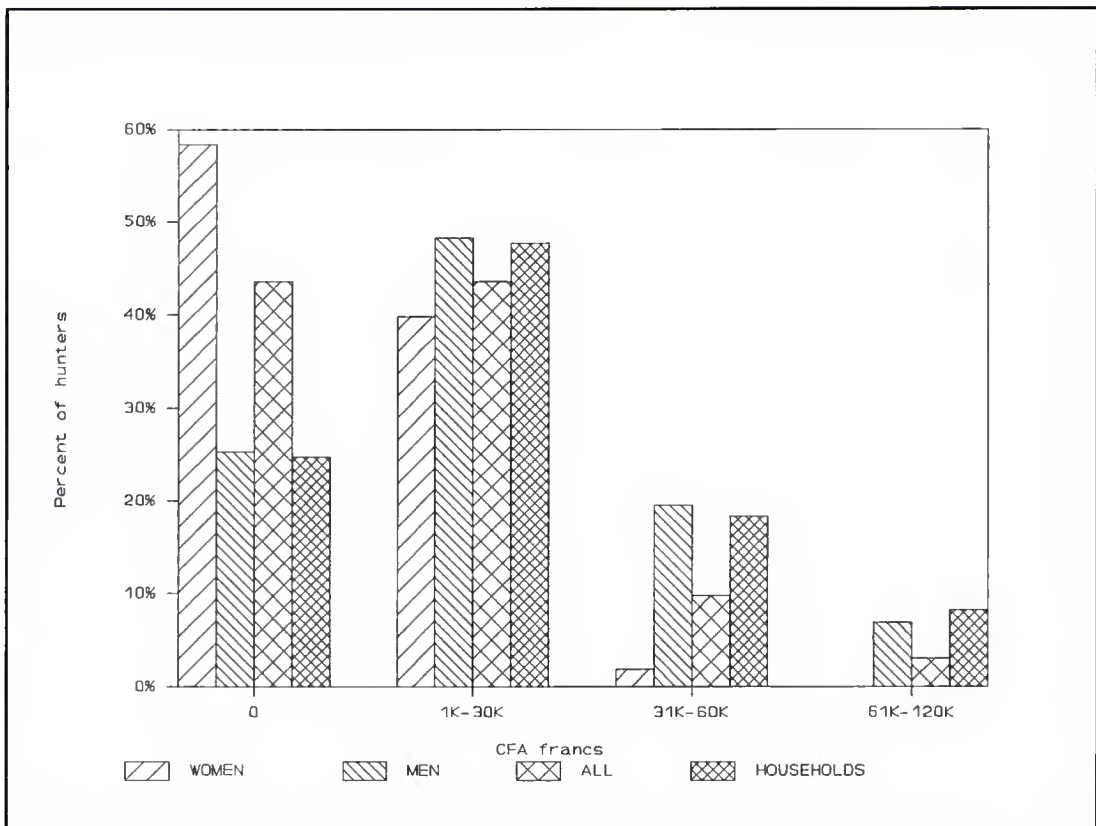


Figure 5.11: Annual Returns from Net Hunting (CFA francs)

Notes: One outlying value is excluded: a household with estimated annual returns of 146,000 CFA francs.

Captures are attributed solely to the person carrying the net or spear which killed the animal. Returns assume that all marketable meat is sold.

Differences between women and men, and between individuals and households, are statistically significant: $|t| \geq 2.97$, $p < 0.01$.

The greatest returns for an individual hunter from a single hunt were three *C. callipygus* weighing 39 kilograms and worth an estimated 7,000 CFA. Another hunter caught seven animals in a single day: four *C. monticola*, one *C. callipygus*, one *A. africanus* and one tortoise. These figures on returns per individual hunter are misleading,

suggesting that most participants can expect to receive nothing. If this were the case, they would pursue other subsistence and economic alternatives. But hunters who kill animals share portions with those who help them set and guard the nets, and additional portions with family members who may not even have participated in the hunt. Furthermore, meat is not the only net hunt product: hunters also gather numerous plant foods and materials for consumption and sale. Therefore total net hunting returns, for individuals and for the community, exceed the figures described above.

Table 5.20: Annual Mossapoula Bushmeat Production
(number of animals and value in CFA francs)

<u>Species</u>	<u>Day hunts</u>			<u>Forest camps</u>		
	<u>Price</u>	<u>Number</u>	<u>Value</u>	<u>Price</u>	<u>Number</u>	<u>Value</u>
<i>C. monticola</i>	1,000	1,600.8	1,600,810	500	181.3	90,625
<i>A. africanus</i>	1,000	255.7	255,730	300	50.8	15,225
<i>C. dorsalis</i>	3,000	136.8	410,490	1,200	36.3	43,500
<i>C. callipygus</i>	3,000	85.5	256,530	1,200	14.5	17,400
Other	500	51.0	25,475	100	58.0	5,800
Total		2,254.88	2,549,035		340.8	172,550

Notes: Annual harvest from day hunts is based on 90 observation days. Annual harvest from forest camps is based on 13 observation days, extrapolating for 20 weeks of forest camps in 1994.

Potential earnings for Mossapoula from net hunting, assuming all marketable portions of captured animals are sold, exceed 2.5 million CFA francs per year (Table 5.20). However, with 195 active hunters, annual returns average only 14,000 CFA per person. But Mossapoula residents devote

only 15 percent of their time to net hunting. They could earn over 90,000 CFA per year if they hunted full-time.

Role of Women in Net Hunting

Communal net hunting differs from most other hunting methods across the tropics in the important role that women play. On average, women outnumber men on net hunts approximately 5-3: women comprise 64 percent of the participants. Occasionally, the net hunting group comprises only women. The only cases in which few or no women participated were hunts staged on behalf of tourists, who usually collect a small group of young men. The proportion of women participating when net hunts take place ranges from 4.8-46.0 percent (average 25.9 percent, $SD \pm 12.6$) versus 0.0-35.3 percent of men (average 16.1, $SD \pm 9.1$). Differences in means between women and men are statistically significant: $t = 3.663$, $p < 0.01$. The difference in number of days per year devoted to net hunting by women (mean 66, range 0-158, $SD \pm 40.15$) versus men (mean 42, range 0-118, $SD \pm 31.76$) is also statistically significant: $t = 4.69$, $p < 0.01$.

In a mixed group there is a rough division of labor. The women are generally responsible for carrying the meat, for tending babies, and for gathering additional food items such as leaves, nuts, fruits, and mushrooms. Men too collect these items when they find them, but usually give

them to a woman to carry in her basket. When men find patches of mushrooms or fallen nuts, they call women to collect them.

Women assist with setting up and removing the nets, and play the essential role of guarding the nets while the men are beating. Should an animal run into a net, the nearest person must seize it before it escapes. Many animals outside the net circle are sighted first by a woman, who calls those nearest her to set up their nets to encircle the animal, or to attempt to spear it. In addition, some women own nets, and those that do not often use their husband's or another man's net. Nets often change hands during a hunt, such that one or more men and women may use it for a time. Women also participate in beating, though they tend to be quieter and less active than the men.

Of 589 animals captured during net hunts, 25.5 percent were captured by women. Only men carry spears, so all animals killed with spears were killed by men. The proportions captured by women are roughly similar for all species (Table 5.21). I attributed the catch to the person carrying the net rather than to the net owner, or to the person who first seized the animal, or to the person who spotted the animal. Therefore these figures do not correspond to the actual distribution of meat from captured animals.

Table 5.21: Net Hunt Captures by Women versus Men
(number of animals captured)

<u>Species</u>	<u>WOMEN</u>		<u>MEN</u>		<u>ALL</u>
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>	<u>Number</u>
<i>C. monticola</i>	116	26.4	324	73.6	440
<i>A. africanus</i>	13	18.6	57	81.4	70
<i>C. dorsalis</i>	8	20.0	32	80.0	40
<i>C. callipygus</i>	8	33.3	16	66.7	24
Other	5	33.3	10	66.7	15
All species	150	25.5	439	74.5	589

Notes: Data are from 76 observed net hunts.

The distribution of catches between women and men differs significantly from the null hypothesis that catches by women and men are equal: chi-square = 144.91, $p < 0.01$.

Women's yields from hunting are therefore lower than men's yields. Of the women who do hunt, 58.3 percent catch nothing, compared to only 25.3 percent of men who hunt. Among those hunters who are successful, women's average annual returns from net hunting are considerably lower than those for men, although the differences are not statistically significant (see Table 5.19). The most proficient woman hunter produces an estimated 121.1 kilograms of edible meat per year, worth 44,611 CFA. Both figures are less than half of those for the most proficient man, with 294.4 kilograms of edible meat and 101,389 CFA, but are more than 160 percent of the average for men. In 14 of 60 married households, the woman brings in more meat than the man.

One excuse given by the community for not net hunting on a given day is that "the women have all gone into the forest" to gather mushrooms, caterpillars or to fish. Women

are becoming increasingly responsible for feeding the family, whereas men increasingly pursue salaried employment, with cash income spent on material goods rather than food. However, without men along the women must perform all tasks: carry and set the nets, beat, guard the nets and capture animals, carry the animals, gather other products, and tend children. Because their attention is divided, these hunts tend to be less successful: the beating is less enthusiastic and concerted, the pace is slower, and as a result fewer animals are encountered and captured. Of four net hunts that captured no animals, two involved hunting groups comprised predominantly of women.

Forest Hunting Camps

An important portion of net hunting activity occurs when camps are established in the forest. These camps are generally beyond the range accessible on day hunts. Members of the camps can no longer exploit formal employment or day labor opportunities, and therefore concentrate on hunting, fishing, and gathering.

In 1993, over half of the Mossapoula BaAka moved into forest camps in February and March, the middle of the dry season. There were as many as three separate camps, frequented by market women from Bayanga and Gbabongo coming

to buy meat and sell manioc.¹⁹ The camps shifted every couple weeks, moving gradually further away from Mossapoula. The group that stayed the longest in the forest made its last camp roughly 25 kilometers east of Mossapoula, and finally returned to the village in early December, after ten months in the forest. During the latter months, no market women were visiting their camp with manioc, and they were subsisting principally on wild yams, honey, and meat.

In 1994, there was at least one forest camp during 58 of the 90 observation days. However, forest camps were relatively small and short-lived, lasting no more than two months during two main periods: February-March and July-September. Over 60 percent of Mossapoula residents never moved to forest camps (Figure 5.12). The most any one individual stayed in forest camps was 18 days, corresponding to 73 days for the entire year. On average, Mossapoula residents spent less than 12 days of the year in forest camps ($SD \pm 19.2$).

¹⁹Visits by meat traders to forest camps occur across central Africa (Hart, 1978; Hewlett, 1977; Hewlett et al., 1982; Hudson, 1990; Sarno, 1993).

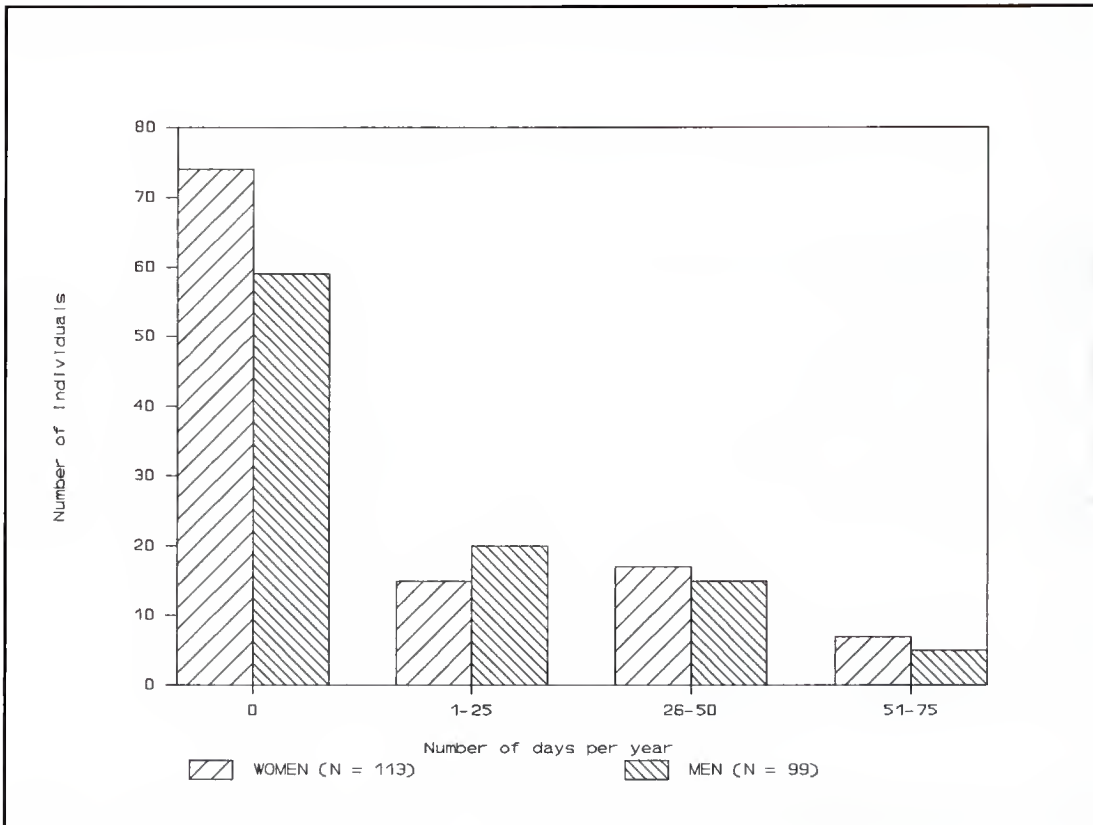


Figure 5.12: Time Spent in Forest Camps

The two camps that I visited in 1994 were no more than ten kilometers from Mossapoula, thus on the edge of the range exploited by day hunts out of Mossapoula (Figure 5.13). These two camps supplied themselves with manioc by sending people back to Mossapoula, Bayanga, or Gbabongo to sell meat and buy manioc. The first camp also obtained manioc from three Bayanga market women who came to buy meat: the women stayed for three days, until their manioc was finished. In this camp, during five days when the market women were present, 77 percent of captured meat was traded (48.5 of 63 pieces), compared to less than 20 percent of

captured meat from Mossapoula day hunts that is sold. Forest camp residents lack the alternative subsistence and economic opportunities available to Mossapoula residents, and therefore depend much more on trading or selling meat.

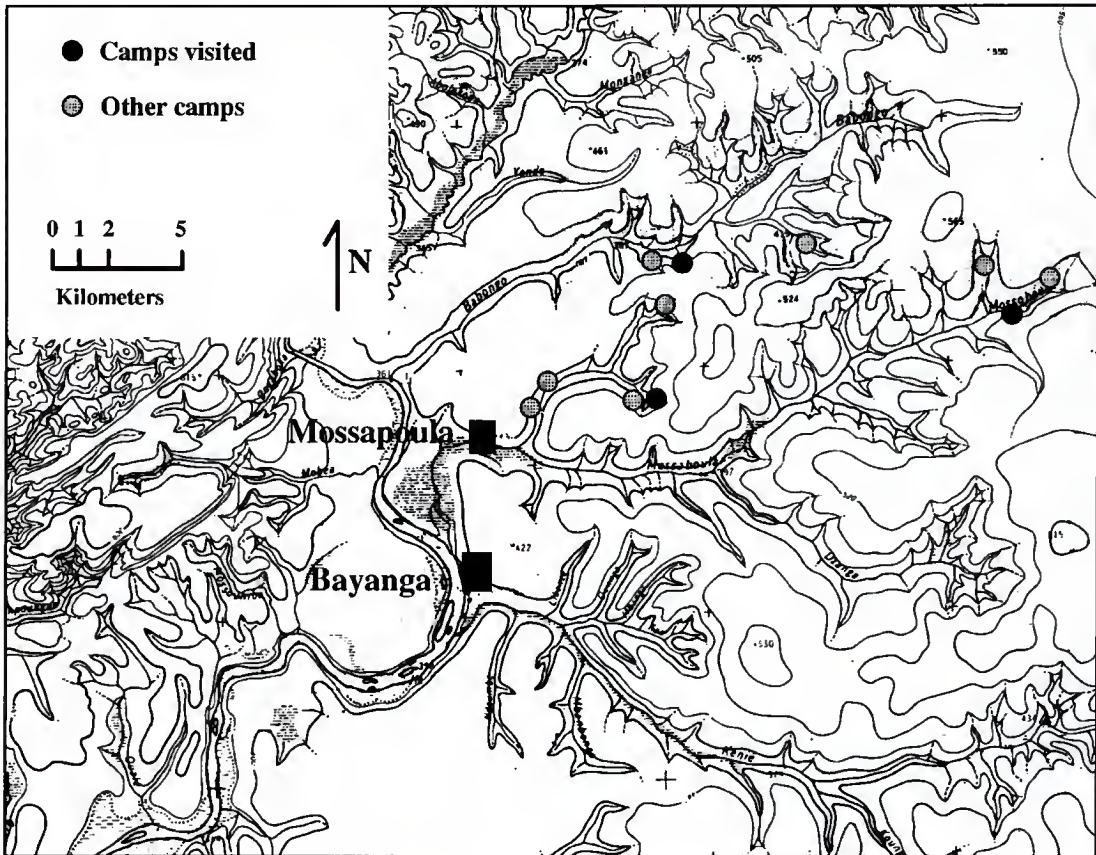


Figure 5.13: Location of Mossapoula Forest Camps

Note: Forest camps move frequently, and "other camps" refer to temporary sites previously occupied by groups I visited.

The principal reason cited for not moving to forest camps, and for not staying longer in the forest, was that

people had to clear and plant manioc fields.²⁰ The forest camping time ends with the beginning of dry season in December, when people return to Mossapoula to plant fields. Therefore those who left the village as late as July did not have time to get very far from Mossapoula, as camps move away only gradually. One group that may have stayed longer returned to the village because people there heard that the project guards were looking for them to chase them out of the park. Other individuals said they preferred to stay in the village where they can find salaried work--they complained they could not earn money living in the forest. Two out of five men in one camp were employed at the same time by a researcher: they spent two weeks working for her and then two weeks in the forest hunting camp. Such mobility would not have been easy if the hunting camp were further from Mossapoula, so establishing a camp near Mossapoula is a way to combine two activities that are important to them. Forest camps are generally family groups lead by more experienced men 40-50 years old. Because several of these men were employed by the logging company in 1994, they stayed in Mossapoula, as did their family members who might have followed them into the forest.

I visited three forest hunting camps for a total of 14 observation days, during which time I accompanied all eight

²⁰Farming was a more important task in 1994 because many fields damaged by elephants had to be replanted.

net hunts that took place. Including infants, the camps comprised 31, 59, and 29 persons respectively. Of this population, only 25-32 percent participated in net hunts at the first two camps, while 45 percent participated in the third camp. People in forest camps hunted slightly less often than do people in Mossapoula: 4.7 times versus 5.0 times per week. Tables 5.22 and 5.23 provide a comparison of net hunts from forest camps with those from Mossapoula.

Table 5.22: Descriptive Statistics
for Forest Camp (N=8) versus Day Hunts (N=73)

	<u>Forest camp hunts</u>		<u>Day hunts</u>	
	<u>Average</u>	<u>SD (+)</u>	<u>Average</u>	<u>SD (+)</u>
Participants				
Women (%)	8.5 (59)	2.74	28.4 (64)	16.90
Men (%)	5.6 (41)	0.99	16.7 (36)	11.16
Total	14.1	2.76	45.1	25.95
Technology				
Nets	8.0	2.29	14.8	4.87
Spears	3.6	0.86	4.6	3.29
Duration				
Casts	18.7	3.95	16.5	4.52
Hours hunting	4.74	0.92	4.10	0.94
Hours out	6.93	1.41	6.67	1.41
Yields				
Captures	5.88	3.98	7.79	6.95
Escapes	8.00	2.60	7.77	4.70
Kilograms	32.56	21.36	42.04	37.53

Notes: Differences between mean values are statistically significant for the following variables: women ($t = 3.31$, $p < 0.01$), men ($t = 2.76$, $p < 0.01$), total participants ($t = 3.35$, $p < 0.01$), nets ($t = 3.94$, $p < 0.01$), casts ($t = -1.35$, $p < 0.1$), and hours hunting ($t = -1.91$, $p < 0.05$).

Differences are not significant for the following variables: spears ($t = 0.81$), hours out ($t = -0.51$), captures ($t = 0.78$), escapes ($t = -0.14$) and kilograms ($t = 0.71$).

Table 5.23: Net Hunt Yields from Forest Camp Hunts (N=8)
versus Day Hunts (N=73)

	<u>Forest camp hunts</u>		<u>Day hunts</u>	
	<u>Average</u>	<u>SD (+)</u>	<u>Average</u>	<u>SD (+)</u>
Kgs/hunt	32.56	21.36	42.04	37.53
Meat/hunt	19.54	12.82	25.22	22.52
g/hunter	1,337.8	759.08	549.5	588.72
g/resident	420.5	238.60	80.6	70.43
g/prot/res	63.1	35.79	12.1	10.56
cal/res	756.9	429.49	145.1	126.78
Total CFA	2,913	1,934.2	8,904	7,919.7
CFA/hunter	202.4	115.74	202.8	197.12

Notes: "Edible meat" is estimated to be 60 percent of the carcass weight (Ichikawa, 1983; Martin, 1985; Tanno, 1976). 100 grams of edible meat contain approximately 180 calories (Bailey and Aunger, 1989; Bailey and Peacock, 1988), and 15 grams of protein (Dwyer, 1985; Martin and Ruberte, 1978).

Returns per Mossapoula resident are calculated for 300 residents.

Differences between mean values are statistically significant for the following variables: g/hunter ($t = -3.75$, $p < 0.01$), g/resident ($t = -13.57$, $p < 0.01$), g/prot/res ($t = -13.57$, $p < 0.01$), cal/res ($t = -13.57$, $p < 0.01$) and total CFA ($t = 2.13$, $p < 0.025$).

Differences are not statistically significant for the following variables: kgs/hunt ($t = 0.71$), meat/hunt ($t = 0.71$) and CFA/hunter ($t = 0.006$).

In forest camps the number of hunters averaged only 14, compared to roughly 40 in hunts from Mossapoula. Therefore, although total yields in hunts from forest camps are on average lower, yields per hunter are more than double those obtained in Mossapoula. Furthermore, yields per resident are five times higher in forest camps. But prices for meat in forest camps are only one-third to one-half those paid in Mossapoula: 300 CFA for *A. africanus*, 1,200 CFA for *C. callipygus* or *C. dorsalis*, and 500 CFA for *C. monticola*; versus 1,000 CFA, 3,000 CFA and 1,000 CFA respectively.

Therefore, total returns per hunt in CFA are much lower in forest camps. But with proportionally fewer hunters to share the returns in forest camps, returns per hunter are identical between the two locations.

Comparative Data

Comparative data on net hunting are available for the BaAka elsewhere in CAR, and the Mbuti from the Ituri forest of Zaïre (Tables 5.24 and 5.25). Figures from Mossapoula net hunting are consistent with these data, except for the larger population size of Mossapoula, higher number of casts per hunt, and higher number of animal encounters. Other researchers describe hunts from forest camps, or from small roadside settlements. Because of the employment opportunities in Bayanga, Mossapoula is an unusually large Pygmy community, though more representative of socioeconomic patterns in central African forests today. Net hunters elsewhere use nets up to 100 meters long, considerably longer than those in Mossapoula which average less than 20 meters in length (Bahuchet, 1985b; Ballif, 1985; Harako, 1981; Hewlett, 1977; Ichikawa, 1983; 1986; Tanaka, 1978; Tanno, 1976; Turnbull, 1963). With up to 1.5 kilometers of nets in all, Mbuti net hunt rounds can take an hour, and an entire hunt comprises only 4-8 casts. Rather than a closed circle, some groups form a semi-circle of nets, and drive animals from some distance away (Bahuchet, 1985b; Hart,

1978; Hewlett, 1991; Hudson, 1990; Motte, 1982; Turnbull, 1963).

Table 5.24: Comparative Net Hunt Statistics

	<u>Mossapoula</u>		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(A)	(B)							
Number of individuals									
Settlement	320	40	39				45	48	
Hunt group	50	14	24	24	20				
Time allocation									
Hunts/week	4.7	4.7	5.9				7	6.5	
Duration									
Hours/hunt	6.6	6.9	6.9	7.0	7.5	8.4	7.3		
Casts/hunt	16.5	18.7	3.9		7	7.3	7.7		
Yields									
Anim/hunt	7.8	5.9		3.5	8.4	3.2			7
Kgs/hunt	42	33	24	29	63	20	33	56	68
Kgs/htr/hr	0.2	0.5	0.2	0.4	0.1	0.3			
Enc/hunt	15.6	13.9		6.5	24.7	9.6			
Vul (%)	50	42	56	34	34	35			

Notes: (A) Day hunts from Mossapoula. (B) Hunts from forest camps. Kgs/htr/hr = kilograms/hunter/hour; Enc/hunt = number of animals encountered per hunt; Vul = vulnerability as percent of encounters captured.

Sources: For Zaïre: (1) Hart, 1978;²¹ (2) Wilkie and Curran, 1991; (3) Tanno, 1976; (4) Harako, 1976; 1981; (5) Ichikawa, 1983; 1986; (6) Hart and Hart, 1986. For CAR: (7) Hudson, 1990.

Duikers, and especially the blue duiker *C. monticola*, are the principal prey of net hunters everywhere. Among the larger red duikers, hunters capture different species in CAR and in Zaïre, although all four species are present in both areas. Species abundance and habitat distribution may vary between the CAR and Zaïre hunting ranges. Although net

²¹These data are for camps where commercial meat traders are present. In the absence of meat traders, hunts are less frequent (4.1 per week), and shorter (5.4 hours and 3.4 casts per hunt).

hunters in Zaïre frequently capture the pygmy antelope *Neotragus batesi*, Mossapoula net hunters say they never catch the animal because it jumps over the nets to escape. *Neotragus batesi* is very rare in the Bayanga region east of the Sangha river, but is occasionally encountered by net hunters.

Table 5.25: Comparative Net Hunt Captures
(percent of individuals by species)

	<u>Mossapoula</u>	<u>(1)</u>	<u>(2)</u>	<u>(3)</u>	<u>(4)</u>	<u>(5)</u>
All duikers	85.5	86.4	76.8			91.8
<i>C. monticola</i>	74.6	79.0	59.2	80.5	62.9	
Red duikers	10.9	7.4	17.6	19.2	37.1	
<i>C. dorsalis</i>	6.8	6.2	6.3	3.8		
<i>C. callipygus</i>	4.1	0.0	0.0	0.0		
<i>C. nigrifrons</i>	0.0	1.2	9.9	9.6		
<i>C. leucogaster</i>	0.0	0.0	1.4	5.8		
<i>A. africanus</i>	11.9	0.0	0.7			8.2
<i>H. aquaticus</i>	0.2	0.0	5.6			
<i>Neotragus batesi</i>	0.0	13.6	9.9			

Sources: For Zaïre: (1) Wilkie, 1989; (2) Ichikawa, 1983; 1986; (3) Harako, 1976; 1981; (4) Tanno, 1976. For CAR: (5) Bahuchet, 1985c.

Table 5.26 presents comparative data showing that hunting yields increase as hunters move further from permanent settlements. In the Mossapoula case, the large drop in yields beyond 10 kilometers results from the fact that net hunts in this range were mainly by small forest camp groups, whereas the other hunts were by large day hunt groups.

Table 5.26: Hunting Yields and Distance from Village
(captures per hunt)

<u>Distance</u>	<u>Mossapoula (N=68)</u>	<u>Zaïre (N=85)*</u>
< 5 kms	6.31	2.51
5-10 kms	12.17	3.65
> 10 kms	7.00	4.23

Source: *Hart, 1979. Distances are estimated from data giving location of hunting camp as "in village", "1-5 kilometers from village" and ">5 kilometers from village."

The importance of net hunting varies from village to village within the Bayanga region, according to the socioeconomic opportunities and constraints BaAka residents face: in particular formal employment opportunities, and patterns of relations with other ethnic groups. In the large Catholic mission villages of Belamboke, Monassao, and Nguengueli where young people have some formal education, and where other economic opportunities may be more accessible, net hunting continues to be practiced, both on day trips and from forest hunting camps. However, these forest camps differ somewhat from those originating in Mossapoula: Monassao and Nguengueli residents often establish forest camps to supply meat to the diamond fields. In Belamboke, the forest camp season ends when school starts. Inhabitants of smaller villages like Koundapapaye and Yobé are currently focusing their attentions on farming rather than hunting, though this focus could change. BaAka residents of Gbabongo and the villages from Lindjombo south are tied more closely to their Bilo neighbors, working as day laborers and net hunting to obtain meat for barter.

Throughout tropical forests, hunting is generally a man's occupation.²² However, communal net hunts always involve men and women. Among Mbuti net hunters in Zaïre, the division of labor is more strict than in Mossapoula, and the roles are reversed, with women always beating while men always guard the nets (Tanaka, 1978; Tanno, 1976; Turnbull, 1963; Wilkie, 1988; Wilkie and Curran, 1991). Net hunts by groups of women have also been recorded among the BaAka elsewhere in CAR (Demesse, 1978).

In the Bayanga region only the BaAka hunt with nets. Other ethnic groups in CAR such as the Banda, Ngando and Ngbaka also historically net hunted, but now depend for the most part on snares and on other economic and subsistence opportunities such as farming and wage labor (Arom and Thomas, 1974; Berry et al., 1986; Bahuchet, 1985b; Demesse, 1978; Sévy, 1972). Net hunting focuses on smaller, more abundant animals than did group spear hunting for big game: porcupines and duikers versus elephants and bush pigs. Net hunting is a more intensive method of wildlife exploitation, more suitable as human populations grow while available hunting range and wildlife resources decline. It is also an efficient method of producing marketable goods--duiker skins

²²Exceptions are Matsigenka women in Peru who accompany men but own dogs, and kill animals with machetes, sticks or traps (Romanoff, 1983). In addition, certain Agta women in the Philippines are also proficient hunters, alone or with men, using dogs, bows, machetes, and traps (Estioko-Griffin, 1985; 1986; Estioko-Griffin and Griffin, 1981).

for export from the 1920s to the 1950s, and meat for the local bushmeat markets since the 1970s (Carpaneto and Germi, 1992). The adoption of net hunting reinforced community structure while increasing the size of residential groups (Bahuchet and Guillaume, 1982; Hart, 1978).

However, if yields from net hunting decline, and if returns to other work such as farming and wage labor increase and become more reliable, communal net hunting is likely to decline in importance. It has already done so for many other ethnic groups including the Batúa or Twa Pygmies of Zaïre (Schultz, 1986). Researchers in Zaïre argue that women's participation depends on the returns to net hunting versus returns to field work: they will pursue whichever activity produces more calories per unit time (Bailey and Aunger, 1989; Wilkie and Curran, 1991). And if women choose not to participate in hunting, then net hunting as a technique is no longer viable.

Because they involve large groups of people, net hunting groups and forest camps are also much easier to locate than are snare hunting activities. It is therefore more difficult for net hunters who hunt or camp in protected areas to escape detection by park guards. This factor too may encourage net hunters to adopt cable snares.

The BaAka and other Pygmy groups currently combine net hunting and cable snare hunting (Bahuchet, 1972; Hewlett, 1977; Wilkie, 1989). For example, the BaAka 100 km to the

northeast of Bayanga spend 57 percent of their time each year hunting, and net hunt six times a week from February to August while they are forest camps. These men set 30-40 snares apiece (Hewlett, 1977; 1991). In comparison, Mossapoula hunters devote only 15 percent of their time to net hunting, hunt 4.7 times per week in forest camps, and own less than 20 snares per person. Mossapoula residents hunt less because they face a wider range of subsistence and economic opportunities.

Further to the east in CAR, the BaAka devote over 60 percent of their time to hunting activities, but net hunting comprises only one-third of all hunting activity (Bahuchet, 1975; 1979a). Mossapoula hunters therefore net hunt only slightly less, but have greatly reduced other hunting, for example with crossbows, porcupine snares and spears.

Mossapoula residents will increasingly shift to snare hunting as practiced by Bayanga residents, which allows more intensive exploitation of multiple resources: individuals can harvest meat and earn wages at the same time. Communal values are increasingly being replaced by individualism. For example, meat is not shared with all members of the hunting group, but can be sold by the net owner. Snare hunting is also more suited to individual action, to the production of cash income, and to reduced residential mobility (Bahuchet and Guillaume, 1982). As they seek to emulate the lifestyle of their Bilo neighbors, with a higher

standard of living, the BaAka will adopt snares because the hunting method produces greater incomes for individual hunters.

In dietary terms, the staple for Mossapoula residents is manioc. The protein that they derive from hunting is complemented by fish as well as vegetable proteins.²³ Therefore, people never speak of "meat hunger" as a reason to go hunting. Instead, they speak of "manioc hunger" as a reason for not hunting, or for not establishing forest camps. Manioc hunger keeps them in Mossapoula planting fields, or sends them to Bayanga seeking day work. Likewise, the Mbuti describe camps that are not near villages as "places of hunger" (Ichikawa, 1986), and camps that have no manioc "have no food" (Hart and Hart, 1986). Those BaAka individuals or communities that devote more time to farming spend less time in forest camps, and may also net hunt less.

Traditional BaAka hunting and gathering groups consisted of 30 people, who periodically cooperated with other residential groups within a regional band of 100 people. This regional band exploited an area of 400 square kilometers, or four square kilometers per person, along trails that originated at Bilo villages and extended up to 100 kilometers into the forest (Bahuchet, 1979a; 1985b;

²³Pygmies in Zaïre derive only 50 percent of their protein from wild animals (Bailey, 1985; Wilkie, 1989).

1989). Mbuti bands in Zaïre also comprised 50-100 individuals, with a hunting territory of 150-300 square kilometers, or at least 1.5-3 square kilometers per person (Ichikawa, 1978; 1986; Tanaka, 1978; Tanno, 1976).

Mossapoula residents today have about one-fifth this area available to them (2.7 persons per square kilometer of hunting territory), and must compete with Bayanga and Mossapoula Bilo hunters and gatherers even within their reduced territory.

Researchers describe a seasonal activity cycle for the BaAka and other Pygmies, with clearly defined seasons for caterpillars, fish, and honey, though hunting generally continues throughout the year (Bahuchet, 1972; 1979a; 1985b; 1989; Bailey and Peacock, 1988; Delobbeau, 1989; Hewlett, 1977; Ichikawa, 1978; 1981; Pagezy, 1988; 1990; 1992; Schultz, 1986). In some cases, however, net hunting is primarily a dry season activity, when small bands join together to form larger hunting groups (Harako, 1976; 1981; Hudson, 1990; Turnbull, 1983). Pygmy groups traditionally made seasonal moves away from villages and into forest camps, for as many as eight months of the year, to focus on net hunting, fishing, or honey collecting (Bahuchet, 1979a; Hudson, 1990; Ichikawa, 1978). These traditional activity cycles and mobility patterns have been modified in virtually all cases, but in different ways depending on the ecological and socioeconomic surroundings. Hudson (1990) describes two

alternative adaptations: some groups divide time between sequential options, other groups subdivide and different members pursue alternate strategies simultaneously. In a "group" as large as Mossapoula, both alternatives coexist.

Inter-ethnic relations are often described as a system of symbiotic relations between Pygmies and their neighbors, with the two groups occupying complementary cultural-ecological niches in the ecosystem (Bahuchet and Thomas, 1986; Ichikawa, 1983; 1986; Terashima, 1986). The two groups produce forest products (meat) and agricultural products (manioc) respectively. Trade allows both groups to meet their subsistence needs. In other cases, the Pygmies are described as a distinct ethnic group (Grinker, 1990), or a lower caste within a single society, principal providers of agricultural labor (Bahuchet, 1979a; Berry et al., 1986; Delobbeau, 1989; Pagezy, 1992). But the seasonal demand for agricultural labor, and the growing subsistence and market demand for bushmeat ensure continued hunting despite the adoption of agriculture. Neither description is adequate for Mossapoula today, where the BaAka combine both systems, producing forest products and providing labor, with independent farming as well.

Conclusion

As is the case for other residents of central African forests, the Mossapoula BaAka face many socioeconomic

changes: immigration of other ethnic groups, competition with other hunters, population growth, agriculture, diamond mining, coffee plantations, logging, tourism, missions, government centers, roads and commerce (Abruzzi, 1979; 1980; Bahuchet, 1991; Bahuchet and Guillaume, 1979; Demesse, 1978; Pederson and Wähle, 1988; Wilkie and Curran, 1991; Wähle, 1986). These socioeconomic changes entail ecological changes as well, by exploiting natural resources and converting natural ecosystems to settlements, farms, etc. Current subsistence and economic activities reflect adaptation to the opportunities and constraints that these changes present. In general, however, the BaAka and other Pygmies only respond to changes imposed by others: if others want to hunt, farm, mine, or log areas that Pygmies are occupying or exploiting, they do so. The Pygmies are forced to move elsewhere or adapt to the new conditions. In most cases it is becoming increasingly difficult for them to move elsewhere.

Pygmies everywhere are socially and economically subordinated by other ethnic groups. In the past, their mobility was an important means to escape excessive exploitation and to avoid conflict, particularly their ability to move into the forest for extended periods (Demesse, 1957; Turnbull, 1963; 1965; 1983). Mobility among Mossapoula residents remains high, but as the hunting range declines, as hunting declines in importance relative to

other activities, and as BaAka demand for goods and services increases, east-west or town-forest mobility also declines. Many BaAka seek to increase their independence from other ethnic groups in new ways: by establishing separate settlements, by cultivating manioc, by pursuing formal employment opportunities, and by producing directly for markets--for example, raffia shingle construction and diamond mining. However, by competing for the same resources, they foster resentment from other ethnic groups. Rising human population densities and competition for resources will induce further socioeconomic change in the Bayanga region.

Communal net hunting remains ecologically and economically viable for Mossapoula residents. Net hunting is an efficient method of capturing the most abundant small-medium terrestrial mammals, which are more resilient to hunting pressure than are larger mammals and primates. Fully protected species are rarely encountered or captured. Net hunting as a technique is therefore compatible with regional conservation objectives. However, given the restricted hunting range and the growing human population, Mossapoula net hunting offtakes are now likely to exceed sustainable levels, particularly for the duikers *C. monticola* and *C. dorsalis*. In the long term, net hunting is not ecologically sustainable.

Net hunting is the single most important activity for Mossapoula residents. Hunting complements other subsistence and economic activities, as individuals alternate among activities on a daily basis. Returns from hunting are roughly equivalent to returns from the available alternatives. Net hunters rely on wildlife exploitation for subsistence purposes: harvested meat is either consumed directly, or sold in order to purchase other food items. I did not see evidence of net hunters acting as professional meat suppliers for Bayanga or other urban areas. Daily meat sales from Mossapoula amount to less than 20 percent of net hunting harvests: an average of 2.4 pieces per day are sold to Bayanga market women, while daily harvests average 12.1 pieces.²⁴ Furthermore, the supply of meat from Mossapoula contributes less than 3 percent of Bayanga's daily bushmeat supply, which averages 98 pieces produced each day by local snare and gun hunters.²⁵

Meat sales, even in the forest camps I visited where as much as 77 percent of marketable meat is traded, are part of the subsistence circuit--meat is sold in order to buy manioc, salt, bread...as well as cigarettes and alcohol.

²⁴Data on Mossapoula bushmeat sales are from the project's export/market survey described in Chapter 3 and Appendix 6.

²⁵Calculations of daily Bayanga bushmeat supply are based on annual production figures in Table 4.10, assuming that only 73 percent of snare captures are recovered and marketed.

Net hunting does not contribute directly to regional development: it does not generate income that is reinvested to produce other goods or services. But net hunting sustains human populations who also engage more traditional "development" activities such as logging, mining, and farming.

The following chapter compares net hunting to snare hunting in the Bayanga region, with respect to the ecological implications for wildlife and the economic importance for hunters of each method.

CHAPTER 6
COMPARISON OF BAYANGA CABLE SNARE HUNTING
AND MOSSAPOULA COMMUNAL NET HUNTING

The two principal hunting methods in the Bayanga region are cable snare hunting and communal net hunting. The two methods differ significantly in their implications for the ecosystem, most importantly their impacts on wildlife. They also differ in their implications for the human system, most importantly their economic importance for hunters. Virtually all ethnic groups in the Bayanga region hunt with cable snares, though this "modern" technology is illegal. I have studied snare hunting by accompanying informants, of several different ethnic groups, who reside in Bayanga. In the Bayanga region only BaAka residents hunt with nets, and I have studied net hunting by the inhabitants of Mossapoula. Net hunting is a "traditional" technology that is legal within the Dzanga-Sangha Reserve.

Impacts on Wildlife

This section compares the impacts of the two hunting methods, as practiced in the Bayanga region, on local wildlife populations. A wider range of species is vulnerable to cable snares than to nets. Cable snares are also more destructive, because many animals escape with

injuries, while many captured animals decompose or are eaten by scavengers. But given the number of hunters and the available hunting range, both hunting methods are likely to be unsustainable for the primary game species: oftakes exceed the reproductive productivity of the population.

Captures

Both hunting techniques are non-selective by species, sex, and age. In practice, hunters catch anything they can, though a relatively narrow range of species is vulnerable to net hunters. Thus, snare hunters encounter and kill a wider variety of species (Table 6.1).¹ Net hunters can be selective, as they capture most blue duikers alive and can spare certain individuals, such as pregnant females. Certain species can also be spared, since even animals that are speared are seen and identified before the spear is thrown. On the other hand, cable snares as employed by Bayanga hunters cannot be selective.

¹In contrast, recent immigrants to forests in Latin America hunt a narrower range of species than do long-term residents (Redford, 1992; Redford and Robinson, 1987). Immigrants generally use guns, while indigenous hunters use a variety of methods including guns, bows and arrows, and blowguns.

Table 6.1: Species Captured by Snares versus Nets
(number of species)

	<u>Observed</u>		<u>Reported</u>	
	<u>Snares</u>	<u>Nets</u>	<u>Snares</u>	<u>Nets</u>
Mammals	18	6	33	15
Reptiles	3	3	7	4
Birds	2	2	3	3
Total	22	11	43	22

Notes: The first two columns indicate the number of species that I observed captured by each method. The second two columns indicate the number of species that informants reported could be captured by each method. "Nets" includes animals captured during net hunts by hand, machete, and spear.

The blue duiker *Cephalophus monticola* is the most important prey species for both groups of hunters, yet constitutes only 36 percent of foot and neck snare captures compared to 75 percent of net captures (Table 6.2). While nets select for *C. monticola*, snares apparently select for the larger *C. callipygus*: chi-square = 121.74, $p < 0.01$. All duiker species combined comprise 77 percent of snare captures, and 86 percent of net captures. The four primary prey species (*Atherurus africanus*, *C. callipygus*, *C. dorsalis* and *C. monticola*) comprise 88 percent of snare captures, versus 98 percent of net captures.

Table 6.2: Animals Captured by Snares versus Nets
(number and percent by species)

	<u>Wt</u>	<u>Snares</u>		<u>Kg</u>	<u>%</u>	<u>Nets</u>		<u>Kg</u>	<u>%</u>
		<u>N</u>	<u>%</u>			<u>N</u>	<u>%</u>		
<i>C. monticola</i>	4.5	38	36	172	18	440	75	1,993	61
<i>C. callipygus</i>	15.0	36	34	539	55	24	4	359	11
<i>A. africanus</i>	3.1	11	11	35	4	70	12	220	7
<i>C. dorsalis</i>	16.0	7	7	112	12	40	7	640	20
Other	--	13	12	118	11	15	2	50	1
All species	--	105	100	976	100	589	100	3,262	100

Notes: Snare data are for foot and neck snares only. Wt is the average species weight for all recovered snare and net captures. N is the number of observed animals captured by each method. Kg is the total biomass in kilograms.

The distribution of captures across species differs significantly for the two hunting methods: chi-square = 134.78, $p < 0.01$. Comparing only *C. monticola* and *C. callipygus*, the difference in distribution of captures remains significant: chi-square = 121.74, $p < 0.01$.

Net hunting therefore specializes in capturing small to medium-sized (3-25 kilograms) terrestrial mammals in dry upland forest. Other animals are rarely encountered, or are able to escape. Very few animals escape injured, though some are wounded with spears, and no animals killed are lost to scavengers or decomposition. Snare hunting is much more indiscriminate, capturing animals weighing from 100 grams to 300 kilograms: from rats and squirrels to bongo and buffalo. Duikers and porcupines also dominate snare captures, but many larger animals escape injured. For every two animals captured, one escapes injured. Relative to nets, snares are much more likely to injure and kill protected species. In addition, snare hunting is wasteful:

one-fourth of captures are lost to scavengers and decomposition.

Capture rates from non-selective snares and nets should reflect actual sex ratios in the population (Alvard, 1994; Dubost, 1980). Both methods capture female duikers, including pregnant and lactating females, more frequently than males (Table 6.3). Assuming that the sex ratio at birth is 1:1, these data suggest that mortality rates from natural factors are higher for males than for females, perhaps because males require larger home ranges and are more mobile. But if hunters continuously remove more females than males, one would assume that males would be more numerous in a hunted population. Non-selective hunting techniques such as cables and nets should then capture more males than females.

Table 6.3: Sex Ratios of Animals
Captured by Snares versus Nets
(number of individuals, female/male ratio)

	<u>Snares</u>			<u>Nets</u>		
	<u>Female</u>	<u>Male</u>	<u>Ratio</u>	<u>Female</u>	<u>Male</u>	<u>Ratio</u>
<i>C. monticola</i>	20	10	2.0	234	187	1.3
<i>C. callipygus</i>	17	12	1.4	13	11	1.2
<i>A. africanus</i>	4	3	1.3	23	45	0.5
<i>C. dorsalis</i>	2	1	2.0	28	12	2.3

Notes: Differences in sex ratios between hunting methods are not statistically significant for any species: chi-square ≤ 1.498 . However, assuming a 1:1 ratio in the population, both snares (chi-square = 4.2, $p < 0.05$) and nets (chi-square = 11.82, $p < 0.01$) are selective for females of all species, except for nets which are selective for male *A. africanus*.

Contrary to the duikers, *A. africanus* females, relative to males, are much less vulnerable to nets than they are to snares.² Snares are often set on trails identified as *A. africanus* trails. Perhaps female animals tend to restrict their movements to these well-established trails. In accordance with the Mossapoula net hunting data, Emmons (1983) finds that females are only half as numerous as males in both hunted and non-hunted populations in Gabon. If males are more numerous than females, then snares represent a potential threat to porcupine populations because of their bias towards females. Alternatively, males may be more mobile than females, and are therefore encountered more frequently by census takers, net hunters, and gun hunters.

Sustainability

Methods for calculating sustainable harvest rates depend on parameters that are exceedingly difficult to measure. The biology of the primary game species is not well known, particularly with respect to how these species respond to hunting pressure. Survey methods are not well developed for counting small cryptic animals in forests. Finally, hunting oftakes are difficult to monitor when much hunting activity is illegal. Theoretical models for sustainable harvest rates and population density calculations depend on numerous assumptions that may be

²However, the snare sample size is extremely small.

violated in practice. Extrapolations of hunting offtakes may likewise be invalid. Nevertheless, the sustainability of hunting offtakes is of interest both from a conservation perspective and from a development perspective. Therefore, with the above caveats, I explore the available data to evaluate the sustainability of wildlife harvests in the Bayanga region.

Whether or not hunting offtakes by snares and nets are sustainable depends on actual population densities and reproductive rates. I can only roughly estimate these two variables within broad ranges. Theoretical models also suggest a range of sustainable harvest rates (Appendix 3). In most cases, actual harvest rates by snares or nets fall within the range of possible sustainable levels for the four primary game species (Table 6.4). The exceptions are that snare offtakes of *C. callipygus* and net offtakes of *C. dorsalis* exceed all estimated sustainable levels.³ In addition, net harvests of *C. callipygus* equal maximum sustainable levels. On the other hand, *A. africanus* harvests may be sustainable by either method, and snare harvests of *C. monticola* may also be sustainable. The cases of *C. dorsalis* snare harvests and *C. monticola* net harvests are ambiguous.

³However, line transect and net hunt encounter density estimates are most likely to underestimate *C. callipygus*, as well as *A. africanus*, populations in the Bayanga region. Snare encounters and density estimates at other sites suggest that densities for these two species may be higher.

Table 6.4: Harvest Rates by Snares and Nets
(individuals per square kilometer by species)

	<u>Snares</u>	<u>Nets</u>	<u>Total</u>	<u>SH</u>
<i>C. monticola</i>	3.3	14.6	17.9	0.24-23.01
<i>C. callipygus</i>	3.1	0.8	3.9	0.01-0.81
<i>A. africanus</i>	1.0	2.3	3.3	0.27-11.88
<i>C. dorsalis</i>	0.6	1.2	1.8	0.01-1.13

Note: SH is the number of individuals per square kilometer that may be sustainably harvested each year, as calculated in Appendix 3.

Based on the matrix of sustainable harvest levels presented in Appendix 3, I have calculated an index of sustainability, defined as the number of cells in the matrix less than or equal to the actual harvest divided by the total number of cells. The higher this index, the more likely that hunting is unsustainable (Table 6.5).

Table 6.5: Sustainability Index by Species
and Hunting Method

	<u>Snares</u>	<u>Nets</u>	<u>Combined Hunting</u>
<i>C. monticola</i>	0.667	0.958	0.979
<i>C. callipygus</i>	1.000	0.979	1.000
<i>A. africanus</i>	0.333	0.667	0.806
<i>C. dorsalis</i>	0.933	0.979	1.000

Notes: See Appendix 3 for the matrix of sustainable harvest levels in the Bayanga region, according to line transect survey and net hunt encounter density estimates, and to theoretical sustainable harvest rates.

The index of sustainability is equal to the number of cell values in the matrix less than or equal to the actual harvest divided by the total number of cells for each species. The higher the index, the more likely that hunting is unsustainable.

The index permits comparisons between species and between hunting methods. *C. callipygus* and *C. dorsalis* are likely to be overexploited by both hunting methods, and the

data strongly suggest that combined hunting pressures on this species are unsustainable. The combination of snare and net harvests is also likely to overexploit *C. monticola* populations, with net harvests a more significant threat. Of the four primary game species, *A. africanus* is the least at risk from either hunting method, and the least likely to be overexploited in the Bayanga region.

For three of the four primary game species in the Bayanga region, legal "traditional" net hunters harvest more animals per unit area than do illegal "modern" snare hunters. However, in areas like the Mossapoula net hunting range, both snare and net hunters are active. The two hunting methods are complementary: snares threaten especially *C. callipygus*, while nets are most dangerous to *C. monticola* and *C. dorsalis*. Where both hunting methods are practiced, all three duikers are at risk of overexploitation. In addition, gun hunters exploit the entire Bayanga region. Therefore, total offtakes by local hunters exceed the combined totals of nets and snares.

However, these figures may underestimate sustainable harvest rates for *A. africanus* and *C. monticola*, two species which appear to be relatively resilient to commercial hunting pressure across central Africa. These species continue to be exploited when larger animals like the "red" duikers *C. callipygus* and *C. dorsalis* virtually disappear from bushmeat markets where hunting pressure is strong.

They are often replaced by smaller rodents which prefer cultivated areas, for example the cane rat (*Thryonomys* spp.). In many cases it is difficult to disassociate the effects of hunting from those of habitat change: human exploitation of forests alters habitat through farming, logging, and mining. But hunting always accompanies these other activities.

The estimated sustainable harvest rates are based solely on population densities and reproductive parameters within a closed system, and do not account for immigration from relatively unexploited areas. This immigration can boost wildlife productivity within hunted areas. In the case of the duikers, migrating animals tend to be young animals leaving their parents and seeking territories of their own. But captured animals by both snares and nets are mainly adults (Table 6.6). The data on age classes, based only on number of molars, may be too imprecise. Immigrating young may be in the subadult class with complete dentition. Neither method captures many young animals, i.e., still nursing.

Table 6.6: Age Structure of Snare and Net Captures
(number of individuals by age class)

	<u>Fetuses</u>	<u>Number of Molars</u>			<u>Subadult</u>	<u>Adult</u>
		<u><1</u>	<u><2</u>	<u><3</u>		
<i>C. monticola</i>						
Snares	1	0	0	2	4	27
Nets	56	1	8	28	71	303
<i>C. callipygus</i>						
Snares	1	0	0	0	4	23
Nets	1	0	4	5	3	10
<i>C. dorsalis</i>						
Snares	1	1	0	0	1	4
Nets	6	1	2	3	5	29
<i>A. africanus</i>						
Snares	1	--	--	--	1	6
Nets	--	--	--	--	18	50

Notes: I did not dissect uteri, and therefore only recorded fetuses large enough to detect by touch. Actual pregnancy rates may have been considerably higher.

Subadult and adult duikers all have complete dentition (3 molars): animals were classified as subadults if their reproductive organs were not fully developed, or if they were considerably below average adult weights.

Differences between the two hunting methods in age structure of captures are significant only for *C. callipygus*: chi-square = 13.97, $p < 0.01$. For the other two duiker species chi-square ≤ 0.752 .

Economic Importance

This section compares the two hunting methods in terms of their economic importance for local people: cable snare hunters in Bayanga, and net hunters in Mossapoula. Cable snare hunting is more productive than net hunting, in terms of returns per individual hunter. As a result, snare hunting is more likely to be a full-time activity when it is pursued. Net hunters are more likely to pursue several activities simultaneously, including hunting.

Employment and Time Allocation

Snare hunting is generally a man's activity, but not all men in Bayanga snare hunt: roughly 100 men, 25 percent of the population, may be active snare hunters at any one time.⁴ These 100 hunters represent only four percent of the Bayanga population as a whole. In contrast, net hunting is a communal activity involving men, women and children. Participation is therefore much higher: only eight percent of Mossapoula adults and adolescents do not hunt.

Although a smaller proportion of Bayanga residents hunt, relative to Mossapoula residents, Bayanga snare hunters devote more time to this activity. Hunting is often the primary source of income for Bayanga snare hunters. An active snare hunter may therefore devote 220 days per year to hunting. Mossapoula residents, on the other hand, spend on average only 56 days per year hunting, and at most 175 days. Some researchers emphasize the contrasts between "village" or "river" peoples who fear the forest on the one hand, and Pygmy "forest" peoples on the other (Delobbeau, 1989; Turnbull, 1961). This is not the case in the Bayanga region, where snare hunters may spend more nights in the forest than do the BaAka. A Bayanga snare hunter spending on average three nights per week in his forest camp spent 150 nights in the forest in 1994, compared to an average for

⁴Perhaps twice that many know how to hunt with snares.

Mossapoula residents of less than 13 nights and a maximum of 73 nights. Bayanga snare hunters therefore compete with Mossapoula and Yandoumbé net hunters for wildlife resources. Hunting ranges overlap, but because the BaAka are subordinate and avoid conflict with Bilos, their available hunting range is reduced by snare hunters.

Both groups of hunters pursue mixed economic strategies, switching from one to another as conditions change. But for Bayanga residents, hunting is more likely to be a full-time occupation when it is pursued, and they alternate among activities on a monthly or weekly basis. For Mossapoula residents, who depend on the cooperation of others in their community, and who alternate among activities on a daily basis, net hunting is only one of several part-time activities pursued simultaneously.

Returns

Returns per hunter from captured animals in kilograms, calories, or CFA francs are 8-12 times higher for snare hunters than for net hunters (Tables 6.7 and 6.8). This may explain why hunting can be a full-time activity with snares, but not with nets. Annual income for a snare hunter can exceed 300,000 CFA, versus 100,000 CFA for the most proficient net hunter, or 146,000 CFA for the most proficient household.

Table 6.7: Weekly Returns per Hunter:
Snares versus Nets

	<u>Snares</u>		<u>Nets</u>	
	<u>Average</u>	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>
Kilograms	16.11	36.15	1.90	3.85
Calories	28,998	65,070	3,424	6,924
CFA francs	5,403	16,400	667	1,355

Note: Kilograms refer to edible meat, 60 percent of total carcass weight.

Data on returns are mutually exclusive: in kilograms and calories assuming all meat is consumed, and in CFA francs assuming all meat is sold.

Table 6.8: Returns per Person/Day Hunting:
Snares versus Nets

<u>CFA francs</u>	<u>Range</u>	<u>Average</u>	<u>SD</u>
Snares	0-8,300	1,627	1,884.61
Nets	0-2,000	185	306.08
<u>Grams</u>	<u>Range</u>	<u>Average</u>	<u>SD</u>
Snares	0-18,900	3,721	4,508.86
Nets	0-5,700	507	873.21

Notes: Grams of edible meat equal 60 percent of total carcass weight.

Data are for 18 snare hunters (153 person/days) and 219 net hunters (2,994 person days).

Differences in daily returns between the two methods are statistically significant with respect to CFA francs ($t = 9.82$, $p < 0.01$) and grams ($t = 8.64$, $p < 0.01$).

Compared to Bayanga residents, Mossapoula residents generally receive lower wages for day labor or formal employment. Assuming a range of formal employment earnings from 1,200 to 7,500 CFA per week, average net hunting returns lie below the range, whereas snare hunting returns lie within the range. Therefore, snare hunting is more likely to sustain local residents who hunt full time. Net

hunting is not pursued full time because the returns are too low relative to alternative employment opportunities.

Mossapoula hunters also receive lower prices for the meat they produce (Table 6.9), especially when they sell the meat in forest camps.

Table 6.9: Variation in Bushmeat Prices
(CFA francs)

	<u>Bayanga</u>	<u>Mossapoula</u>	<u>Forest camps</u>
<i>C. callipygus</i>	3,800	3,000	1,200
<i>C. dorsalis</i>	3,800	3,000	1,200
<i>C. monticola</i>	1,500	1,000	500
<i>A. africanus</i>	1,500	1,000	300

Note: Prices are post-devaluation (January, 1994).

Total annual biomass harvests per square kilometer are roughly equal for Bayanga snare hunting and Mossapoula net hunting (Table 6.10). Bushmeat production per resident is also roughly equal for Bayanga and Mossapoula, when net hunting from forest camps is included. Snares therefore allow a smaller proportion of hunters to exploit a wider area and supply meat to a larger population than does net hunting. However, the snare harvest represents fewer but larger animals than the net harvest. To the extent that smaller animals are more resilient to hunting pressure, net hunting is the more sustainable exploitation method.

Table 6.10: Annual Bushmeat Production by Snares and Nets, and Bayanga Beef Sales

	<u>Bayanga</u> <u>snares</u>	<u>Mossapoula</u> <u>nets</u>	<u>Bayanga</u> <u>beef</u>
Total kgs	125,599	14,172	21,535
kg/km ²	126	129	**
Edible kg/person			
total	22.0	23.1	5.2
excluding exports	17.1	18.7	5.2
Total animals	10,552	2,254	107
Animals/km ²	10.55	20.49	**
Animals/person	4.22	7.51	0.04
Total CFA francs	21,609,275	2,549,035	21,535,000
CFA/hunter	360,155	13,072	--

Notes: **No cattle are raised within the Bayanga or Mossapoula hunting ranges. Cows that are butchered in Bayanga are raised outside the area, 50 kilometers to the north in the savanna near Salo.

Bayanga snare hunting range is 1,000 km², and population is 2,500 inhabitants. Mossapoula net hunting range is 110 km², and population is 300. Net hunt data include day hunts and hunts from forest camps that occur within the day hunting range.

Roughly 22 percent of bushmeat production by snares is exported from Bayanga, while 19 percent of bushmeat production by nets is exported from Mossapoula.

Total wildlife exploitation is perhaps 40 percent higher than production by snares or nets alone. Total Bayanga bushmeat production includes both snare and gun harvests. Total Mossapoula bushmeat production includes net and snare harvests, and harvests from forest hunting camps outside the day hunting range. Although Bayanga hunters export 26 percent of bushmeat production outside the Bayanga region, these exports are partly offset by purchases from Mossapoula and Yandoumbé--roughly 3 percent of the Bayanga daily supply from each village. Mossapoula hunters sell on

average 20 percent of meat production to Bayanga residents, but Mossapoula residents never buy meat from Bayanga hunters. Only Bayanga residents buy beef, and beef remains a small proportion of total meat consumption in Bayanga, at less than 15 percent.

Conclusion

Compared to net hunting, snare hunting is more destructive in ecological terms and more productive in economic terms. Therefore, although net hunting is more ecologically sustainable, net hunters are increasingly adopting cable snares because they are more economically remunerative. The choice of hunting technique in the Bayanga region has important implications for biodiversity conservation and the ecosystem, as well as for socioeconomic development and the human system. The following chapter discusses these implications.

CHAPTER 7
HUNTING AND CHANGE: INTEGRATING CONSERVATION
AND DEVELOPMENT?

This dissertation concludes by re-examining the role of hunting within the cultural ecology framework. Hunting is a traditional activity for all residents, BaAka and Bilo, of the Bayanga region. This chapter reviews the implications of hunting, as currently practiced by Bayanga and Mossapoula residents, for biodiversity conservation and socioeconomic development, and for efforts to integrate conservation and development through the sustainable exploitation of wildlife. The chapter concludes with recommendations for further research.

Hunting and Cultural Ecology

The cultural ecology framework emphasizes the interactions of two systems: the ecosystem and the human system (Butzer, 1989; Grossman, 1977; Moran, 1981a; Turner, 1989). The entire set of interactions between all components of the two systems is exceedingly complicated. This dissertation therefore focuses on one activity that integrates the two systems, namely hunting, and in turn examines the effects of hunting on both the ecosystem and the human system. Hunting practices in Bayanga and

Mossapoula are adapted to the natural environment, in particular the behavior and abundance of particular prey species, and the structure of the forest. They are also adapted to the socioeconomic environment, most importantly the availability of alternative employment opportunities, and the market for bushmeat.

The Ecosystem

Wildlife exploitation depends on the wildlife resource base itself: the types of wildlife resources available, their abundance and distribution, and their response to exploitation. The two principal hunting methods in the Bayanga region target the most abundant small-to-medium game species.¹ They are relatively easy to capture by either method: snare hunters set snares along abundant and clearly visible trails that the game species regularly use; and net hunters surround and search patches of thick brush where the animals hide rather than fleeing. The two smallest game species, *A. africanus* and *C. monticola*, appear to be relatively resilient to hunting pressure.

Hunting alters the natural environment primarily by killing and injuring animals, and may cause long-term

¹Hunting in Latin America, in contrast, increasingly targets the largest species of mammals: deer, peccaries, primates, and tapir (Ayres et al., 1991; Redford, 1992; Smith, 1976b). The larger species in the Bayanga region--elephants, bongo, and buffalo--are seldom hunted because they are dangerous, and few hunters have guns.

population reductions in all species: total current offtakes by all hunting methods probably exceed sustainable levels for most species. Reductions in wildlife population densities diminish herbivory, seed predation, and seed dispersal. In this way, hunting alters relations between plants and animals, and the entire ecosystem changes (Bodmer, 1994; Dirzo and Miranda, 1990; Janzen, 1983; Rapport et al., 1985; Redford, 1992; Sauer, 1941a; 1963b). At the same time, other human activities may benefit wildlife by increasing the availability of food and shelter in secondary vegetation regrowth patches: for example, by logging, cutting trees to harvest honey or fruit, and farming (Bahuchet, 1978; Hart and Petrides, 1987).

The Human System

Local human systems affect wildlife exploitation in the Bayanga region in several ways. First, as in other relatively isolated forest areas around the tropics, a number of political actors influence conservation and development activities: indigenous peoples, immigrant peoples, government officials, and international organizations. Each actor has a different agenda regarding the use of natural resources: subsistence consumption, market production, employment, foreign aid, etc.

At the local level, officials often lack the commitment and resources to adequately enforce conservation

legislation. International donors like WWF, the World Bank, and USAID promote biodiversity conservation and sustainable development. However, these organizations represent important sources of funds for a country like CAR.

Therefore the national government, although its commitment to conservation may be weak, tends to support projects that promise foreign currency and employment. But at the same time that it is promoting wildlife conservation through the Dzanga-Sangha project, the government has granted concession rights in the same forests to private logging companies. In practice, the logging company and the project clash with respect to their use of natural resources, and their relations with local residents.

Second, economic factors determine the pressure on wildlife resources. Bushmeat represents a major subsistence and economic resource, a principal means to obtain necessary food items and other commodities. The local market alone is sufficient to ensure that hunting can support a significant proportion of local residents, particularly when alternative activities fail. Economic activities, and logging in particular, have drawn large numbers of immigrants to the Bayanga region. Many of those who cannot obtain formal employment depend on hunting, while periodic logging company closures and Dzanga-Sangha project lay-offs induce many more local residents to hunt. In addition, the demand for

bushmeat in urban centers and by diamond miners continues to grow, further increasing pressure on wildlife resources.

Third, social factors such as relations among ethnic groups influence patterns of wildlife exploitation. The BaAka historically were hunter-gatherers who traded bushmeat, other forest products, and labor for crops and tools provided by neighboring Bilos. These patterns continue today. However, traditional relations have changed as immigrants have moved into the area, as a cash economy has replaced barter, as new employment opportunities have become available, and as the BaAka have settled into permanent villages. Many BaAka now cultivate as well, at times selling crops to Bilos. The BaAka have opportunities for formal employment with the project and the logging company, and in some cases operate their own diamond mines. BaAka residents therefore produce less surplus bushmeat for sale, while demand by Bilos has grown. The creation of a market for bushmeat, and the lack of jobs, has encouraged some Bilos to become part- or full-time hunters themselves.

People also hunt because they enjoy hunting: they like to eat meat, and most ethnic groups in the Bayanga region are hunters by tradition. While they are hunting, either on day hunts, or in forest camps, the BaAka appear happier and more confident--songs and dances are more frequent than in Mossapoula. Hunting, from Mossapoula or from forest camps, frees them temporarily from the subservient role into which

they fall in the presence of Bilos. Snare hunters too enjoy the freedom of action and the opportunity to "be one's own boss" that hunting permits.

Hunting and Change

The BaAka traditionally adapted to their environment by living in mobile and dispersed groups of less than 100 people (Bahuchet, 1985b). As they depleted wildlife resources in one area, they moved their camp elsewhere. Other ethnic groups likewise lived in small dispersed groups, combining hunting with cultivation. Such hunting was probably sustainable because hunting was for subsistence purposes, human population densities were low, and technologies were relatively simple.

These conditions no longer exist today. The human population in the Bayanga region is growing and settlements are more permanent; more efficient and indiscriminate technologies such as firearms and cable snares are common; and production is for external markets as well as subsistence. The available hunting area is being reduced as the CAR and neighboring Congo create protected areas, and as logging and mining activities occupy and damage habitat.

Researchers elsewhere have emphasized the role of hunting technology in influencing components of the human system (Demesse, 1980; Hudson, 1990; Steward, 1955; 1968):

...[H]unting technology appears significantly to influence other aspects of Pygmy society and culture, including hunting strategies, mobility, settlement patterns, gender relations, intra- and extra-familial relations, political authority, ethnic relations, symbolic relationships to the forest, and possibly also ritual organization (Roscoe, 1990, p. 691).

In the Bayanga region today, causality operates in the opposite direction, as suggested by Godelier (1977): components of the human system determine the choice of technology and hunting practices.

Cultural adaptation to the environment may have created the ethnic distinctions evident today, with the BaAka tending to hunt and gather in the forest, and other ethnic groups depending more on farming in villages or fishing along rivers.² The two groups exploited different sets of resources, maintaining access to all resources through inter-ethnic trade. But as a result of ecological and socioeconomic change, ethnic interdependence is declining. The BaAka and Bilos now compete in exploiting the same resources--wildlife, diamonds, jobs--and ethnic distinctions are becoming less meaningful.³ As is the case with the Oto and Twa of Zaïre, the two groups differ mainly by the number

²In fact, both groups have long practiced a mix of activities including hunting and farming (Arom and Thomas, 1974; Bahuchet, 1985a; 1985c; Bahuchet and Guillaume, 1979; 1982; Bahuchet and Thomas, 1986; Delobea, 1978; 1989; Vansina, 1983; 1985a; 1985b; 1986; Wilkie and Curran, 1993).

³The same competition for resources occurs between Pygmies and their neighbors elsewhere, for example between the Baka and Mbimu to the north-west of Bayanga (Pederson and Wähle, 1988).

of people involved and the time allocation to each activity, as well as the technical means employed (Pagezy, 1992).

Kent (1989) argues that different mobility strategies differentiate ethnic groups, but in this respect too, patterns are converging in the Bayanga region.

Cultural differences originally influenced how the two groups used resources, for example, communal spear hunting by the BaAka, versus communal net hunting and individual snare hunting by their neighbors. But cultures are increasingly converging with respect to hunting practices, subsistence and economic activities, settlement patterns, etc. Both groups have adapted new technologies such as cable snares, nets, and guns. Both groups also exploit new resources and new opportunities (bushmeat, diamonds, formal employment) created by local, regional, national, and international actors. Both groups exploit a wide range of subsistence and economic opportunities simultaneously at the group level and intermittently at the individual level. Settlement and mobility patterns converge as both groups increasingly pursue the same economic opportunities: the logging company, the project, hunting, farming, and diamond mining.

As elsewhere in African forests, bushmeat represents an important source of income (Caldecott, 1986; Colchester, 1993; Falconer, 1990; Infield, 1988; Redford, 1992).

Hunting is how people "feed" themselves directly as well as

indirectly--by selling the meat to obtain other necessities such as manioc, salt, sugar, coffee, tobacco, raffia wine, clothes, school fees, etc. But expectations are changing with development, and economic "needs" now include radios, cassette players, watches, sunglasses, bicycles, etc. For those people without formal employment, hunting must keep them at a level roughly equal to their employed neighbors, thus the pressure on wildlife resources increases because hunters need to earn more in order to meet their needs.

For these reasons, as incomes rise, local hunters invest in hunting methods that produce higher returns per individual hunter, though they may require a higher initial capital investment. Mossapoula hunters are switching from net hunting to cable snare hunting, and Bayanga hunters are switching from snares to guns. The adoption of cable snares reflects changes occurring in BaAka community structure: the community cooperation that net hunting requires is declining, with less meat sharing among hunters, and individuals selling what they capture. Net hunting conflicts with wage-earning opportunities for men, whereas snare hunting does not. The sexual division of labor is increasingly significant, with women feeding the family, while men seek income-earning opportunities.⁴ More cable snare hunting by Mossapoula residents may also hasten the

⁴Cash is rarely spent on food.

decline of wildlife resources, as hunters seek higher returns from a constant or declining hunting range.

Additional gun hunting is likely to increase conflicts between Bayanga residents and the project. Many hunters try to avoid the costs of legally registering their guns, yet they lose a much greater capital investment if their gun is confiscated as compared to their snares. Gun hunters are as indiscriminate as snare hunters in their choice of prey species, although they may shoot the largest animals in a group first, and these are more likely to be adult males. Guns are more productive than snares, killing more animals, and wasting less--though some animals that are shot may escape injured or may die and cannot be found. Like snares, guns target terrestrial mammals like duikers and bush pigs, but are also used on larger animals including elephants. Guns also harvest many large diurnal primates which are relatively safe from snares and nets, for example monkeys, chimpanzees, and gorillas. The larger the animal killed, the greater the returns. Because of the quantity of meat produced, and the need to repay the cost of the weapon and to purchase ammunition, gun hunting also emphasizes the production of meat, skins⁵ and ivory for markets. If demand in local markets is insufficient, gun hunters will seek to export meat to larger urban centers outside the

⁵Valuable skins are those of large cats (leopard and golden cat) and reptiles (python and crocodiles).

area, further increasing the pressure on wildlife resources. Skins and ivory must also be sold outside the region, as there is little local demand for these products.

Biodiversity Conservation

Subsistence and economic activities practiced in the Bayanga region include shifting cultivation, hunting, selective logging, small-scale mining, tourism, etc. In theory, these activities are compatible with wildlife conservation. They create small and temporary disturbances from which the ecosystem can recover as the damaged areas regrow and are repopulated by dispersal from the surrounding forest.

However, people engaged in these activities also depend on hunting for additional income and a more varied diet. Some researchers go so far as to argue that other economic activities would not be possible without the dietary and income subsidy that hunting provides (Redford, 1992; 1993). Economic activities, in particular logging and diamond mining, also create and maintain relatively large population concentrations. Hunting techniques and intensity surrounding these settlements are no longer sustainable. Snare and net hunting in the Bayanga region both concentrate on the most abundant small-to-medium terrestrial mammals, in particular the duikers (*Cephalophus callipygus*, *C. dorsalis*, and *C. monticola*) and the brush-tailed porcupine (*Atherurus*

africanus). Despite the continuous hunting pressure for at least two decades, these species have not been exterminated, and may be somewhat resilient to current harvest levels. However, the available information on population densities and reproductive rates suggests that hunting probably overexploits wildlife resources, since BaAka and Bilo populations both hunt using nets, snares, and guns. Further human population growth will only increase pressure on wildlife resources as a source of food and income.

Cable snares are particularly damaging to wildlife because they are indiscriminate and wasteful. The available data suggest that only *C. callipygus* is overexploited. But given the number of snares and snare hunters in Bayanga, cable snare hunting is likely to be unsustainable for all wildlife species. Net hunting by Mossapoula residents also can be unsustainable, particularly in the case of the blue duiker *C. monticola* and possibly the bay duiker *C. dorsalis*. The Mossapoula population is also relatively large with respect to the wildlife resource base, particularly given the limits on their hunting range imposed by park boundaries and competing hunters. In many areas snare and net hunting are practiced simultaneously, combined with gun hunting as well.

Neither the BaAka nor the Bilos exhibit a "conservation ethic" in their exploitation of natural resources. Hunters are "opportunistic predators" rather than conservationists

(Alvard, 1994; Hames, 1991; Lahm, 1993a): they capture as many animals of any species, sex, and age as they can. Any meat that is not eaten can be sold, and vice versa. In Bird-David's terms (1992a, 1992b), they "procure" resources from the environment, taking whatever they see. Snare hunters repeatedly say "if I had more snares, I would put them here...". Net hunts that are very successful are never cut short because enough animals have been captured; instead hunters often push on longer because tomorrow might not be so successful.⁶

People cut down trees in order to collect fruit, "koko" leaves, and honey. On one occasion an older woman shook her head at a "payo" nut tree that had been cut to harvest honey, saying "what will your children eat tomorrow?" The more usual response was the one I received: "there are lots of other payo trees; look, there's one over there."

With respect to animals, some hunters admit that there are fewer animals near Bayanga or Mossapoula, and that they have to go further to hunt than they did a few years ago. But no one believes that they can exterminate local wildlife by overhunting with nets or snares. Overexploitation has already substantially depleted wildlife in forest regions of CAR close to large urban centers, but in these cases, people

⁶Unsuccessful net hunts may also be extended in order to catch at least something.

blame the lack of wildlife on the excessive use of guns (Moussa, 1992).

In the Bayanga region, hunters continue to exploit forest resources as if they are unlimited, perhaps because they lack economic alternatives and must emphasize short-term needs at the expense of long-term sustainable resource management. In addition, cultural values determine how people perceive risk, and they react only to dangers that they perceive (Kottak and Costa, 1993). Thus, they may fail to anticipate future scarcity resulting from overexploitation because resources have always been abundant in the past. Furthermore, Bird-David (1992a, 1992b) argues that "hunter-gatherers" like the BaAka trust the environment to share its resources with them according to their needs, assuming abundance rather than scarcity. Other Central African ethnic groups, who may be described as "horticulturalists", view the environment in the same way: they too live in mobile settlements, and individuals also combine farming with hunting, gathering, and trade (Guddemi, 1992).

Socioeconomic Development

The residents of the Bayanga region want "development". To most, development means permanent formal employment with the logging company, "like how it was when the Yugoslavs

[Slovenia Bois] were here."⁷ They are not concerned that this development be "sustainable". They define sustainable development as continuous economic progress for the human system over time, but resource exploitation need not be sustainable. Diversification of economic activities protects the human system from collapse when major resources decline (Goldman, 1995).

Most residents are immigrants from elsewhere in CAR or Congo, and are very mobile. Therefore, if local resources are exhausted, they will move elsewhere to pursue other opportunities, as they have always done in the past. A long-term commitment to a particular village or region does not dominate behavior. Because they are not restricted to a specific resource base and defined territory, the costs to individuals of prudent resource use outweigh the benefits (Gadgil et al., 1993).

Indigenous knowledge of wildlife, intimate though it may be, focuses on harvesting or "mining" as opposed to managing these resources. Therefore the only costs incurred in hunting are the time investment and capital investment in equipment. Although they may result in more sustainable long-term exploitation, any resource management practices impose additional short-term costs (Alvard, 1994), which

⁷But people are also dissatisfied with the new logging company, complaining that Sylvicole de Bayanga has not hired everyone in Bayanga, pays poorly, and provides fewer services (such as free lumber). The Dzanga-Sangha park project provides some formal employment as well.

people are unwilling to bear in the absence of short-term benefits.

In any case, local people lack a sense of ownership with respect to the forest or its resources: these belong to the government, to the logging company, to the project, or to God. Local residents have no tenure rights, and no way to exclude other users from exploiting these open access resources. Diamond miners, Congolese and Cameroonian elephant poachers, new immigrants and hunters from outside the region all come and go at will. If local people do not hunt the animals, someone else will, and they lack incentives to conserve resources for the future.

Even if people choose to stay in the region, they will not necessarily use resources sustainably. Instead, when one local resource is exhausted, they will switch their attention to exploiting other resources in the area. For both Bayanga and Mossapoula residents, hunting is one in a suite of economic and subsistence occupations among which they opportunistically choose to engage themselves. Hunting is probably not indispensable to either group, as there are other potential activities to occupy them.⁸

The data on returns from both hunting methods attest that hunting remains a viable alternative occupation for both BaAka and Bilo residents of the Bayanga region.

⁸However, the alternative sources of protein such as beef, fish, or vegetable proteins may not be affordable or adequate to meet dietary needs.

Hunting produces incomes roughly equivalent to what members of either group earn in other occupations. Wildlife resources buffer the local economy, allowing people to remain in the region while they seek formal employment, and providing a fall-back option sustaining them when other opportunities fail.

Hunting in the Bayanga region is not the basis for economic development, though it provides important subsistence and economic resources to complement other activities. All local peoples pursue a suite of subsistence and economic activities, including hunting. Similar flexible, mixed economic strategies have been described elsewhere in tropical forests (Eder, 1984; 1988a; Endicott and Bellwood, 1991; Griffin, 1981; 1984; 1989; Jorgensen, 1995; R. Peterson, 1992b; Rai, 1982; Rambo, 1979a; 1982b). Rural households tend to choose diversification over resource management in labor allocation (Goldman, 1995). By not committing themselves to any single long-term activity, people are always ready to take advantage of new and better opportunities that may arise (Bird-David, 1992a; 1992b; Endicott, 1979; Sellato, 1994). The boom-bust economic history of the Bayanga region teaches local residents that opportunities are temporary and must be exploited quickly and fully while they last.

Sustainable development cannot be based on the consumptive use of wildlife: wildlife resources are

limited; exploitation and habitat loss from other economic activities threaten to reduce productivity; and human populations and expectations continue to rise. Even non-consumptive wildlife exploitation like tourism may not support sustainable development under these conditions.

Integrated Conservation and Development

Biodiversity conservation and socioeconomic development projects, and the impacts of both on forest peoples, are generating a great deal of controversy around the world. Can the relationship between humans and the environment in tropical forests be ecologically and economically sustainable? To what extent does wildlife represent a renewable natural resource that can contribute to local economic development without being rapidly depleted? These questions face local peoples, governments, and international organizations in the Amazon (Browder, 1989; 1992; Clay, 1988; Foresta, 1991), in central Africa (Bailey, 1982; Brown and Singer, 1990; Carroll, 1986b), and in Asia (Caldecott, 1986; Headland, 1988; W. Peterson, 1981).

In addition to the Dzanga-Sangha project, several other conservation and development projects in central African rain forests are currently being planned or implemented. Korup National Park in Cameroon is the oldest, dating back to 1986. Korup combines core protection areas with agricultural development activities in a large buffer zone

(Brown and Singer, 1990; Nicoll, 1991; Republic of Cameroon, 1989; Sayer, 1992; Sweeting et al., 1992). Congo has recently established the Ndoki-Nouabalé National Park adjoining the Dzanga-Sangha project (Chadwick, 1995; Linden, 1992; Nganga et al., 1990). A similar park is envisioned in south-eastern Cameroon (Lamarque et al., 1990; Rodgers et al., 1991). Finally, the government of Zaïre in the summer of 1992 officially designated the Ituri Okapi National Park (Von Richter et al., 1990). All these parks face similar problems of conserving forest wildlife and ecosystems, promoting tourism in isolated and difficult environments, and managing development schemes to address the socioeconomic needs of local people who have occupied park lands or whose livelihood is closely linked to the exploitation of natural resources (wild animals and plants) in these areas.

The ICDP model depends on community participation in developing and managing conservation and development programs. In the Bayanga case, the park was created first by government decree, and the project then sought to foster community participation. But the local "community" is extremely diverse: several thousand people, in several villages, of several different ethnic groups. Local people do not recognize a collective interest in conservation, because resource use strategies differ significantly among individuals and groups, and wildlife resources are not

recognized to be scarce (Barrow et al., 1993a; Lawry, 1990). Under such conditions, rational self-interested individuals will not act to achieve common or group interests (Olson, 1971; Ostrom, 1990).

The project has attempted to create community institutions to address its development objectives and distribute revenues from tourism. The first quickly collapsed because of internal disagreements and misuse of funds: the Association Communautaire de Yobé-Sangha included representatives of employment guilds such as farmers, fishermen, market women and merchants. The second was created in 1994: the Comité de Développement de Bayanga has representatives from all Bayanga neighborhoods and other villages. It too faces serious internal disagreements over how to distribute money and manage local development projects.

Local people have no interest in conservation: they do not believe that the forest or its wildlife could ever be used up. And the possibility that this could happen will induce few people to change current practices--just as they once moved to Bayanga, they can move elsewhere seeking new opportunities socioeconomic or ecological conditions change. In the absence of local interest in conservation, the project seeks to foster community support by providing services and benefits through revenues generated by tourism, in order to show that "conservation pays".

But the project cannot match what the logging company can provide, nor can it meet people's expectations that are based on their experience with Slovenia Bois' Yugoslav government-subsidized generosity: employment for all; free schools, health care, and housing; no restrictions on hunting; etc. In a town of 2,500 people,⁹ the project provides only about 40 full-time jobs: game guards, tourist guides, and administrative staff. Many of these individuals were hired from outside the Bayanga region or are recent immigrants. The project hires an additional 100 persons on a temporary basis, but periodically lays them off because of budget problems. Nor have tourism revenues been significant, until perhaps 1994 when the park received 100 visitors each month, generating 200,000 CFA per month in community development funds. The project also provides health and education services, but to date project benefits have been insufficient to change behavior with respect to wildlife exploitation.

Local residents therefore have difficulty recognizing the benefits of conservation and of the project. But both impose significant and visible costs on local people: elephants destroy their crops; the project guards arrest them for hunting and confiscate their property; and they are restricted in pursuing other activities as well, for example

⁹An additional 2,500 residents live within the Dzanga-Sangha Special Reserve.

diamond mining and farming. Any efforts to enforce collective interests through long-term conservation, by the government or the conservation project, must restrict hunting activities. Local people strongly resent these efforts which conflict with their individual interests in meeting short-term subsistence and economic needs. Restrictions on hunting, and protection for elephants that damage crops, are perceived by the population as "forbidding us to eat" (Kretsinger, 1993).

Hunting has not been banned outright in the region. Local people retain the rights to exploit wildlife with certain hunting methods in the Reserve. In practice, however, only BaAka net hunting continues to be legal. The principal hunting method for other ethnic groups, namely cable snares, is illegal. The only alternative for these people are firearms, which are too expensive to operate legally. Because local residents incur no management costs in their current harvest practices, any wildlife management and conservation practices introduced by the project increase costs and reduce yields. The benefits of such activities are much less clear and immediate.

Integrated conservation and development projects in Bayanga and elsewhere promote the sustainable exploitation of wildlife as being compatible with both their conservation and development objectives. However, with respect to hunting by local people in tropical forests, it is extremely

difficult to determine whether exploitation is sustainable. Measurements of key parameters are extremely uncertain: population densities, reproductive rates, dispersal rates, and harvest rates. The biology of important game species such as duikers is not well known; they are small, cryptic, and difficult to count in thick forest vegetation; and legal and illegal hunting activities are difficult to monitor. These same conditions make management of wildlife populations and their exploitation extremely difficult in this environment.

So long as immigration cannot be restricted, a fundamental contradiction exists between conservation and development. Economic development of any kind--a logging company, a conservation project--that offers employment, builds roads, and provides services, attracts migrants to the area. Employees hired elsewhere bring extended family members, and others come to seek employment. Immigration since 1970 has greatly increased both Bilo and BaAka populations in the Bayanga region. Those unable to find formal employment for months and even years can meet their subsistence and economic needs by hunting. People do not come to the Bayanga region to hunt, but hunting often sustains them during periods when more desirable formal employment is not available.

The concept of an integrated conservation and development project is therefore in serious jeopardy.

Development is necessary to provide alternative subsistence and economic opportunities for local residents, so they depend less on hunting, yet immigration augments natural population growth rates, and increases pressure on wildlife resources. Recent research similarly concludes that ICDP conservation and development objectives are fundamentally contradictory, particularly in the long term (Barrett and Arcese, 1995; Brandon and Wells, 1992; Kremen et al., 1994; Oates, 1995; Southgate and Clark, 1993; Stocking and Perkin, 1992; Wells and Brandon, 1993). Development raises human population densities and expectations, while conservation at best maintains stable wildlife resources. The returns from sustainable exploitation, particularly through hunting for bushmeat, cannot match ever-growing human needs.

Recommendations for Conservation and Development,
with Particular Reference to the Dzanga-Sangha Project

The critique above and the recommendations below apply specifically to the Dzanga-Sangha ICDP in Bayanga, but are also relevant to integrated conservation and development efforts elsewhere in African forests and worldwide. Recommendations emphasize continued monitoring of ecosystem and human system components, as well as interventions addressing wildlife management and hunting practices.

Monitoring

Population censuses of prey species, particularly the duikers *C. monticola*, *C. callipygus*, and *C. dorsalis*, are indispensable for assessing the impacts of hunting and for guiding conservation efforts. I conducted day-time surveys, looking and listening for animals. Night censuses are probably more effective, though they may be more dangerous given the abundance of elephants, gorillas and gun hunters active at night. Pellet counts and duiker calls are additional methods that may be effective. If resources are available, a radio-telemetry study would provide the most accurate data. The method I have proposed, based on encounters by net hunters, provides a relative abundance measure that can be monitored over time and across the region.

Data on wildlife exploitation are also essential. Net hunting is the easiest hunting activity to track. A single informant can record information such as the number of net hunts per week, as well as the number of captured animals by species. The most effective way to monitor snare and gun hunting is to conduct neighborhood surveys of bushmeat markets. Most bushmeat is sold outside of the Bayanga market, from people's homes. I hired a 15 year-old school-boy to tour his neighborhood daily and note each location selling meat, the quantity by species, the hunter's name, and whether he used snares or a gun. Limitations of this

kind of survey are that it turns up few protected species, and species identification is not exact.

Another factor influencing hunting is the price of bushmeat in local markets. The price of bushmeat fluctuated a great deal in 1994, in response to devaluation and efforts by local authorities to control prices. Bushmeat prices are by the piece, according to species. These can be compared with the prices of the alternatives, i.e. beef and fish. The availability and price of beef can easily be monitored at the Bayanga public market. Small groups of cows are periodically walked down from the Salo savanna: for a week there will be beef every day, as the cows are killed one by one. Then there will be no beef at all until another group arrives.

Demographic data are essential for conservation and development efforts. In order to monitor demographic and occupational trends, villages within the reserve could be censused 2-4 times per year. The simplest method is to count and map all occupied houses. In addition, one or several informants can provide the number and names of the occupants, and where they are that day--location and occupation. The resulting data reveal patterns of fission and fusion within villages, as well as temporary/seasonal shifts to other villages or hunting, diamond, and logging camps. The data also reveal patterns of employment: formal employment with the conservation project or logging company,

and informal employment such as day labor, mining, hunting, gathering, etc.

Snare Hunting

Snare hunting is ecologically destructive and is likely to be unsustainable for all species. However, it is important to note that snare harvests are lower per unit area than are net hunting harvests for three of the four primary game species: *C. monticola*, *C. dorsalis*, and *A. africanus*. Furthermore, conservation concerns must be balanced with the needs of local residents to feed themselves.

Snare hunting can be reduced by two types of actions: increasing the costs of snare hunting, and reducing the demand for bushmeat. Park authorities can increase the costs/risks of snare hunting with more consistent surveillance of the entries into town: the main road, foot trails, and the river. The hunters I accompanied made no particular effort to conceal themselves, entering Bayanga via footpaths or canoe during the day. People coming in along the main road often wait until after dark.

The project can perhaps reduce the demand for bushmeat by increasing the supply and/or reducing the price of beef. Currently beef is available in the market only half of the time or less. Beef is more expensive than bushmeat: 1,000-1,200 CFA/kilogram versus 900-1,000 CFA for a Peters duiker

quarter that weighs 2-3 kilograms fresh. But when cattle are brought to Bayanga an animal is butchered every other day, with most of the meat sold the first day. People have money to buy meat, and could switch from bushmeat to beef if the latter were always available and if the prices were more competitive.

Hunting cannot be separated from other economic activities, and many local residents combine snare hunting with other employment. Accordingly, logging trucks, particularly those travelling from logging sites back to the sawmill, should be monitored. They may be bringing bushmeat into Bayanga, from animals captured in cable snares set by the loggers themselves.

Efforts to stop snare hunting generate considerable resentment among Bayanga residents. Their anger runs deep and must not be ignored by the project, because it could again explode as during the major riot in November, 1993. Although cable snares are illegal throughout the country, the law is enforced only where there are anti-poaching guards. In practice, snare hunters caught are not punished: only their snares are confiscated. Furthermore, the portion of the Dzanga-Sangha Reserve that lies west of the Sangha river is not patrolled. This leniency is important in soothing some of the anger, and could be formalized as a compromise solution--"here is an area where you can hunt to feed yourselves."

Finally, it may be possible to balance human needs with conservation objectives if less destructive hunting techniques can be introduced. Injured escapes as well as losses to decomposition and scavengers can be reduced with more regular surveillance of snare lines. An intriguing approach would be to develop cable snares methods that select for animals of particular sizes, that prevent animals from struggling and injuring themselves, and nooses that release if the cable is broken. Hunters may be persuaded to adopt less wasteful hunting methods, particularly if these methods do not greatly increase costs and reduce yields.

Changes in hunting legislation could also change hunting practices. Guns are the only legal alternative to cable snares for most Bayanga residents. Relative to snares, guns are a less wasteful hunting method with fewer injured escapes, and fewer captured animals lost. Guns are also easier to monitor: who is using them, where and when. However, they are prohibitively expensive to own legally and to operate. In particular, the "taxe d'abattage" or head tax for species like the blue duiker exceed the market value of the animal's meat. Currently this tax is not levied, except for tourists, so it serves no practical purpose with respect to CAR residents.

The laws pertaining to protected species also place all duikers on the "partially protected" list B, whereas these are the most abundant and frequently killed game species.

In addition, although cable snares are illegal throughout CAR, they are probably the most commonly used hunting technique in the country. Laws that cannot be enforced consistently appear to rural people as the arbitrary exercise of power by authorities: the laws should be simpler and more practical.

Immigration is a serious threat to conservation efforts, yet development of any kind, including benefits from conservation, attracts additional immigrants. If possible, any further immigration to Bayanga and to the Dzanga-Sangha Special Reserve must be strictly controlled. Snare hunting is one of the first activities new arrivals can undertake, though it is not the reason for their move to Bayanga.

Development benefits should accrue primarily or exclusively to long-term local residents. One complaint about the project and the logging company is that they hire people from outside the region rather than local people. This only exacerbates local unemployment, fosters additional resentment, and encourages local residents to hunt.

Net Hunting

Although net hunting is a "traditional" technology practiced for subsistence purposes, net hunting oftakes may be unsustainable as well. BaAka populations are expanding

while their hunting range is declining, and competition with other hunters is increasing.

If net hunting continues to be practiced, and if it is to remain sustainable, the hunting range should be extended. At present, the park boundaries entirely preclude the legal establishment of forest camps by Mossapoula residents beyond their day hunting range. In order to reduce hunting pressure in this range, the project should permit controlled net hunting by Mossapoula residents in the Park north of the Mossapoula river. They only go out for a few weeks a year, and their prey species would not be threatened by such intermittent hunting and the corresponding low annual offtakes per unit area. The camps would be easy to monitor in terms of longevity, number of occupants, number of visiting traders, and quantity of meat produced.

In addition, the Mossapoula hunting range must be strictly protected from competition by outsiders, particularly cable snare hunters. The project could assist in this respect.

However, anecdotal information suggests the guards may be harder on the BaAka than on others they find poaching. In part, the BaAka are considered to be socially inferior to Bilos and are very submissive to Bilo game guards. There are no BaAka game guards. Net hunting camps are larger and louder, and therefore much more easy to locate, than are snare hunter camps. The Mossapoula BaAka still describe in

anger one instance where the guards destroyed or confiscated their pots and nets from a hunting camp in the park. One camp that I visited returned to Mossapoula abruptly upon hearing that the guards were looking for the camp. The BaAka said they were "afraid of being beaten." The project should train and hire BaAka game guards, and monitor guard activities to ensure that ethnic biases do not guide law enforcement.

At the same time, many local residents complain that the project, and all foreigners, only come to help the BaAka. Although to outsiders the BaAka seem most in need of help, benefits that discriminate among ethnic groups generate additional resentment, which manifests itself in inter-ethnic exchanges. The project needs to more clearly demonstrate benefits to Bilo residents.

Recommendations for Further Research

The Bayanga region is a fascinating research site, where virtually everything happening in forests across the tropics occurs simultaneously: logging, mining, safari hunting, poaching, subsistence hunting, market hunting, tourism, conservation projects, etc.

In ecological terms the site is unique, with significant populations of forest elephants, gorillas, chimpanzees, and bongo. Most importantly, these animals can be observed because they frequent numerous marshy clearings

and mineral licks. In addition to rare and endangered species, many more abundant species are exploited by local hunters for subsistence and markets. Therefore the Bayanga region is also a valuable site for examining the effects of hunting on prey species, and on the ecosystem in general. The most important research to complement the data on offtakes in this dissertation would be to provide more accurate information on the wildlife resource base: what are actual population densities for the primary game species, and what are actual reproductive rates in hunted populations? This information would permit more accurate determinations of the sustainability of hunting practices.

The Bayanga region is also an important site for studying the effects of other subsistence and economic activities on the ecosystem. To understand better the nature of relations between the ecosystem and the human system, comparative studies of the many economic activities would be useful: logging, diamond mining, coffee plantations, fishing, raffia wine tapping, raffia roof shingle production, etc. In each case, studies could examine the economic importance of the activity in terms of employment and income, relative to other economic activities, and the impacts of the activity on the targeted species and the ecosystem in general.

Each population center in the Bayanga region comprises a different ethnic mix, and pursues a different economic

strategy. Within settlements and ethnic groups, subsistence and economic strategies also change over time as ecological and socioeconomic conditions change. The area is therefore promising for comparative studies of change: how do different ethnic groups relate to the environment, and how do they adapt to changing ecological and socioeconomic constraints and opportunities? Why do members of the same ethnic group adopt different strategies in different locations? For example, why do the BaAka in some locations cultivate farms, while elsewhere they continue to depend mainly on hunting and gathering, or on wage labor? Why do different ethnic groups in a single location adopt different strategies?

With respect to hunting and wildlife resources in particular, research on other villages and other hunting methods would provide valuable comparative information. With the baseline information provided in this dissertation, long-term research can monitor changes in hunting methods, intensity, and objectives for snare and net hunters.

APPENDIX 1
WILDLIFE SPECIES NAMES

LATIN

MAMMALS

Aonyx congica
Atherurus africanus
Atilax paludinosus
Bdeogale nigripes
Cephalophus callipygus
Cephalophus dorsalis
Cephalophus leucogaster
Cephalophus monticola
Cephalophus nigrifrons
Cephalophus sylvicultor
Cercocebus albigena
Cercocebus galeritus
Cercopithecus nictitans
Cercopithecus cephus
Cercopithecus neglectus
Cercopithecus pogonias
Colobus guereza
Cricetomys emini
Dendrohyrax arboreus
Felis aurata
Funisciurus pyrrhopus
Genetta servalina
Genetta tigrina
Genetta victoriae
Gorilla gorilla
Herpestes naso
Hippopotamus amphibius
Hyemoschus aquaticus
Hylochoerus meinertzhageni
Loxodonta africana
Lutra maculicollis

ENGLISH

Congo clawless otter
Brush-tailed porcupine
Marsh mongoose
Black-footed mongoose
Peters' duiker
Bay duiker
White-bellied duiker
Blue duiker
Black-fronted duiker
Yellow-backed duiker
Grey-cheeked mangabey
Crested mangabey
Greater white-nosed guenon
Moustached guenon
De Brazza's guenon
Crowned guenon
Black and white colobus
African giant rat
Tree hyrax
Golden cat
Cuvier's tree squirrel
Servaline genet
Large-spotted genet
Giant forest genet
Gorilla
Long-nosed mongoose
Hippopotamus
Water chevrotain
Giant forest hog
Elephant
Spotted-necked otter

FRENCH

Loutre à joues blanches du Congo
Athérure africain
Mangouste des marais
Mangouste à pattes noires
Céphalophe de Peters
Céphalophe bai
Céphalophe à ventre blanc
Céphalophe bleu
Céphalophe à front noir
Céphalophe à dos jaune
Cercocèbe à joues grises
Cercocèbe agile
Hocheur
Moustac
Cercopithèque de Brazza
Cercopithèque couronné
Colobe guereza
Rat géant
Daman d'arbres
Chat doré
Rat palmiste
Genette servaline
Genette tigrine
Genette géante
Gorille
Mangouste à long museau
Hippopotame
Chevrotain aquatique
Hylochère
Eléphant
Loutre à cou tacheté

<u>LATIN</u>	<u>ENGLISH</u>	<u>FRENCH</u>
<u>MAMMALS (continued)</u>		
<i>Manis gigantea</i>	Giant pangolin	Pangolin géant
<i>Manis tetradactyla</i>	Long-tailed pangolin	Pangolin à longue queue
<i>Manis tricuspis</i>	Tree pangolin	Pangolin à écailles tricuspidés
<i>Mellivora capensis</i>	Ratel	Ratel
<i>Nandinia binotata</i>	Two-spotted palm civet	Nandinie
<i>Neotragus batesi</i>	Bates' pygmy antelope	Néotrague de Bates
<i>Orycteropus afer</i>	Aardvark	Oryctérope
<i>Pan troglodytes</i>	Chimpanzee	Chimpanzé
<i>Panthera pardus</i>	Leopard	Léopard
<i>Papio anubis</i>	Olive baboon	Cinocéphale
<i>Perodicticus potto</i>	Potto	Potto
<i>Potamochoerus porcus</i>	Red forest hog	Potomochère
<i>Procolobus badius</i>	Red colobus	Colobe bai
<i>Protoxerus stangeri</i>	Giant forest squirrel	Ecureuil
<i>Syncerus caffer</i>	Buffalo	Buffle
<i>Thryonomys</i> sp.	Cane rat	Aulacode
<i>Tragelaphus euryceros</i>	Bongo	Bongo
<i>Tragelaphus spekei</i>	Sitatunga	Sitatunga
<i>Viverra civetta</i>	African civet	Civette
<u>REPTILES</u>		
<i>Bitis gabonica</i>	Gaboon viper	Vipère du Gabon
<i>Crocodylus cataphractus</i>	Slender-snouted crocodile	Crocodile
<i>Kinixys erosa</i>	Tortoise	Tortue
<i>Osteolaemus tetraspis</i>	Dwarf crocodile	Crocodile
<i>Python sebae</i>	Python	Python
<i>Varanus niloticus</i>	Monitor lizard	Varan
<u>BIRDS</u>		
<i>Agelastes niger</i>	Black guineafowl	Pintade noire
<i>Ceratogymna subcylindricus</i>	Black and white casqued hornbill	Calao
<i>Ceratogymna cylindricus</i>	Brown cheeked hornbill	Calao
<i>Ceratogymna atrata</i>	Black casqued wattled hornbill	Calao

<u>LATIN</u>	<u>ENGLISH</u>	<u>FRENCH</u>
<u>BIRDS (continued)</u>		
<i>Corythaeola cristata</i>	Great blue touraco	Grand touraco bleu
<i>Francolinus lathamii</i>	Latham's forest francolin	Francolin
<i>Francolinus squamatus</i>	Scaly francolin	Francolin
<i>Guttera plumifera</i>	Plumed guineafowl	Pintade
<i>Guttera pucherani</i>	Crested guineafowl	Pintade
<i>Lophaelus occipitalis</i>	Long crested hawk eagle	Aigle
<i>Stephanoaetus coronatus</i>	Crowned eagle	Aigle

<u>LATIN</u>	<u>COLLOQUIAL</u>	<u>FRENCH</u>	<u>SANGO</u>	<u>BAAKA</u>	<u>GBAYA</u>
<u>MAMMALS</u>					
<i>Aonyx congica</i>				Londo	Londo
<i>Atherurus africanus</i>	Porc épic		Ngenze	Ngomba	Ngenze
<i>Atilax paludinosus</i>	Renard		Mgbanza	Libolo/Nganda	Mgbanza
<i>Bdeogale nigripes</i>	Renard		Mgbanza	Buse	Buse
<i>Cephalophus callipygus</i>	Antilope		Ngendi	Musome	Ngendi
<i>Cephalophus dorsalis</i>	Antilope		Gbaibe	Mgbom	Gbaibe
<i>Cephalophus leucogaster</i>	Antilope		Senge	Senge	Senge
<i>Cephalophus monticola</i>	Gazelle		Dengbe	Mboloko	Dengbe
<i>Cephalophus nigrifrons</i>	Antilope		Njombe	Monjombe	Njombe
<i>Cephalophus sylvicultor</i>			Tostao	Bemba	Bemba
<i>Cercocoebus albigena</i>			Nganda	Ngada	Nganda
<i>Cercocoebus galeritus</i>			Tamba	Esadu	Moloka
<i>Cercopithecus nictitans</i>			Tu	Koi	Tu
<i>Cercopithecus cephus</i>			Toakunda	Gbeti	Toakunda
<i>Cercopithecus neglectus</i>				Musula	Daa-li
<i>Cercopithecus pogonias</i>				Mambe	Mambe
<i>Colobus guereza</i>				Kalu	Kalu
<i>Cricetomys emini</i>			Jojo	Gbe	Gbazola
<i>Dendrohyrax arboreus</i>			Yuka	Yuka	Yuka
<i>Felis aurata</i>			Nduku	Nduku	Nduku
<i>Funisciurus pyrrhopus</i>			Ba-da ti keke	Esende?	Kui-te
<i>Genetta servalina</i>			Yomba	Ngele	Zama
<i>Genetta tigrina</i>			Yomba	Ngele	Zama
<i>Genetta victoriae</i>			Yomba	Ngele	Zama
<i>Gorilla gorilla</i>			Ngile	Ebobo	Ngile
<i>Herpestes naso</i>			Mgbanza	Libolo/Nganda	Mgbanza
<i>Hippopotamus amphibius</i>	Renard		Kono	Ngubu	Ngubu
<i>Hyemoschus aquaticus</i>			Mbengene	Mbengene	Mbengene
<i>Hylochoerus meinertzhageni</i>				Beya	
<i>Loxodonta africana</i>	Phacochère		Ndole	Njoku	Folo
<i>Lutra maculicollis</i>				Londo	Londo

<u>LATIN</u>	<u>COLLOQUIAL FRENCH</u>	<u>SANGO</u>	<u>BAAKA</u>	<u>GBAYA</u>
<u>MAMMALS (continued)</u>				
<i>Manis gigantea</i>		Kukuru	Kelepa	Gbakakambia
<i>Manis tetradactyla</i>		Kokolo	Ekadi	Kokolo
<i>Manis tricuspis</i>		Kokolo	Kokoro	Kokolo
<i>Mellivora capensis</i>			Buse	Kpenderekpe
<i>Nandinia binotata</i>			Mboka	Mba
<i>Neotragus batesi</i>			Gwagwa	Coche
<i>Orycteropus afer</i>		Ngbenge	Kpinya	Tongo
<i>Pan troglodytes</i>		Bapela	Sumbu	Dabele
<i>Panthera pardus</i>		Ze	Mbongo	Ze
<i>Papio anubis</i>			Mgbabilo	
<i>Perodicticus potto</i>		Dindiki	Ekoto	Dindiki
<i>Potamochoerus porcus</i>	Cochon	Menge	Ngoya	Ngoya
<i>Procolobus badius</i>			Niao	
<i>Protoxerus stangeri</i>			Esende	
<i>Syncerus caffer</i>		Mgba	Mboko	Yele
<i>Thryonomys</i> sp.		Lele	Bende	Bia
<i>Tragelaphus euryceros</i>	Buffle	Mbongo	Mbongo	Mbongo
<i>Tragelaphus spekei</i>		Mbliya	Mbliya	Mburu
<i>Viverra civetta</i>			Liabo	Liabo
<u>REPTILES</u>				
<i>Bitis gabonica</i>				
<i>Crocodylus cataphractus</i>	Caïman		Mukuakele	Mokakele
<i>Kinixys erosa</i>		Kunda	Kudu	Tana
<i>Python sebae</i>	Serpent boa			
<i>Osteolaemus tetraspis</i>	Caïman	Ngunde	Ngando	Ngando/Kol
<i>Varanus niloticus</i>		Mbarawara	Ngombe	Ngombu

Sources: Blom, 1993; Carroll, 1986c; Dorst and Dandelot, 1970; Haltenorth and Diller, 1977; Kretsinger, 1989.

APPENDIX 2

GAME SPECIES CHARACTERISTICS

Atherurus africanus (Brush-tailed porcupine)

Length: 35-50 cm	Weight: 2-4 kg
Tail: 15-23 cm	Gestation: 3.5 months
Forelimb: 15-19 cm	Number of young: 1
Hindlimb: 15-21 cm	

Cephalophus callipygus (Peters' duiker)

Length: 77-97 cm	Weight: 11-22 kg
Tail: 10-16 cm	Gestation: 7 months
Horns: 2-11 cm	Number of young: 1
Forelimb: 44-52 cm	
Hindlimb: 51-61 cm	

Cephalophus dorsalis (Bay duiker)

Length: 72-89 cm	Weight: 11-25 kg
Tail: 8-15 cm	Gestation: 7 months
Horns: 2-9.5 cm	Number of young: 1
Forelimb: 40-51	
Hindlimb: 47-57 cm	

Cephalophus monticola (Blue duiker)

Length: 49-65 cm	Weight: 3.25-6.75 kg
Tail: 5-12 cm	Gestation: 7 months
Horns: 1-5.5 cm	Number of young: 1
Forelimb: 28-37 cm	
Hindlimb: 32-43 cm	

Notes: Measurements are from hunted animals in the Bayanga region. Reproductive information on duikers is from Vivian Wilson at Chipangali Wildlife Trust, Bulawayo, Zimbabwe. Reproductive information on *A. africanus* is from Rahm (1962).

APPENDIX 3 SUSTAINABLE HARVEST RATES

Method 1

Sustainable harvest rates can be calculated by determining the intrinsic rate of increase for populations of game species, according to the following formula (Cole, 1954; Fa et al., 1995; Hennemann, 1983; Robinson and Redford, 1991; 1994b):

$$1 = e^{-r} + be^{-r(a)} - be^{-r(w+1)}$$

- e = 2.7128 (base of natural log)
- r = (proportion of total population N) maximum intrinsic rate of increase of a population not limited by food, space, resource competition, or predation
- a = age at first reproduction--1.5-2.5 years for duikers, and 2 years for porcupines
- w = age at last reproduction--10 years for duikers, and 8 years for porcupines
- b = (proportion of total population) annual birth rate of female offspring, assuming half the population is female

The formula assumes a constant birth rate (litter size and birth interval) whereas these factors vary over an animal's life span. Furthermore, the formula assumes no mortality in pre-reproductive age classes, for example from predation or disease. Therefore, rather than taking r as the maximum sustainable harvest rate, the methods below calculate a proportion of productivity that is available to human hunters. When this human offtake is combined with natural mortality, total mortality must not exceed productivity.

Robinson and Redford (1991) estimate that 20 percent of productivity (r) is available to human hunters in the case of long-lived species with a life span exceeding 10 years, including duikers. For short-lived species with a life span of 5-10 years, including porcupines, 40 percent of productivity can be sustainably harvested.

	$\bar{y}$	$\bar{b}$	$\bar{r}$	SHR (%)
<i>A. africanus</i>	2-9	0.5-2.25	0.28-0.73	11.2-29.2
<i>C. monticola</i>	0.9-1.7	0.23-0.43	0.11-0.29	2.3-6.0
<i>C. dorsalis</i>	0.8-1.7	0.18-0.43	0.07-0.29	1.6-6.0
<i>C. callipygus</i>	0.7-1.7	0.17-0.43	0.05-0.29	1.2-6.0

Note: y is the total number of young per female per year.

Method 2

The second method likewise calculates a population's maximum intrinsic rate of increase r_m (percent of the population N). The model posits that r_m is approximately equal to the birth rate b_r , and that there is a correlation between birth rate and body size. W is the average weight for the species in kilograms.

Caughley and Krebs (1983) use the following birth rate calculated for a range of species to estimate r_m :

$$r_m \approx b_r = 1.5 * W^{-0.36}$$

The sustainable harvest rate (SHR) is also defined by the following formula (Bell, 1984; Caughley, 1977; Caughley and Krebs, 1983; Western, 1979):

$$SHR = r_m * (1 - N/K)$$

where N = population density
 K = carrying capacity

At carrying capacity ($N = K$), mortality equals natality, and the sustainable harvest rate is 0: any harvesting will reduce populations. Hunting reduces populations below K , to levels where natality exceeds natural mortality. If hunting offtake artificially balances natality and mortality, then hunting can be sustainable (Eltringham, 1984; Peek, 1986). Based on studies of neotropical mammals, Robinson and Redford (1991) estimate that sustainable yields are maximized for population levels between $0.6K$ and $0.9K$ for tropical forest species.

$$SHR = 0.4 * r \text{ (when } N = 0.6K \text{)}$$

$$SHR = 0.1 * r \text{ (when } N = 0.9K \text{)}$$

	<u>W</u>	<u>r_m</u>	<u>SHR (%)</u>
<i>A. africanus</i>	3.19	98.8	9.9-39.5
<i>C. monticola</i>	4.68	86.1	8.6-34.4
<i>C. callipygus</i>	16.54	54.6	5.5-21.8
<i>C. dorsalis</i>	17.82	53.2	5.3-21.3

Method 3

This method assumes that harvests are unsustainable when they exceed 30 percent of the population's reproductive productivity P (Bodmer et al., 1994):

	<u>Litter</u>	<u>Gestations</u>	<u>Young/</u> <u>individual/</u>	<u>SHR (%)</u>
	<u>Size</u>	<u>per year</u>	<u>year</u>	
<i>A. africanus</i>	1-3	2-3	0.50-2.25	15.0-67.5
<i>C. callipygus</i>	1	1-1.7	0.25-0.43	7.5-12.8
<i>C. dorsalis</i>	1	1-1.7	0.25-0.43	7.5-12.8
<i>C. monticola</i>	1	1-1.7	0.25-0.43	7.5-12.8

P is the reproductive productivity of the species, as a percentage of the total population, assuming that half the females are reproductively active, and that half the total population is female. Harvests are sustainable if they do not exceed 30 percent of P.

Sustainable Harvests

The sustainable harvest rates above are predicted theoretically, while population densities can be measured in the field. Given these two variables, it is possible to calculate sustainable harvests for the primary game species in the Bayanga region.

The following tables present a matrix of sustainable harvests according to the sustainable harvest rates described in Methods 1-3 above, and according to the range of population densities estimated from line transect surveys and net hunt encounters.

A. africanus (36 cells)

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>					
		2.7 ^b	3.6 ^b	5.3 ^b	8.3 ^b	10.7 ^b	17.6 ^b
2A	9.9	0.27	0.36	0.52	0.82	1.06	1.74
1A	11.2	0.30	0.40	0.59	0.93	1.20	1.97
3A	15.0	0.41	0.54	0.79	1.25	1.60	2.64
1B	29.2	0.79	1.05	1.55	2.42	3.12	5.14
2B	39.5	1.07	1.42	2.09	3.28	4.23	6.95
3B	67.5	1.82	2.43	3.58	5.60	7.22	11.88

C. callipygus (48 cells)

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		0.9 ^a	0.9 ^b	1.0 ^b	1.1 ^a	1.2 ^b	2.8 ^b	3.3 ^b	3.7 ^b
1A	1.2	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04
2A	5.5	0.05	0.05	0.06	0.06	0.07	0.15	0.18	0.20
1B	6.0	0.05	0.05	0.06	0.07	0.07	0.17	0.20	0.22
3A	7.5	0.07	0.07	0.08	0.08	0.09	0.21	0.25	0.28
3B	12.8	0.12	0.12	0.13	0.14	0.15	0.36	0.42	0.47
2B	21.8	0.20	0.20	0.22	0.24	0.26	0.61	0.72	0.81

C. dorsalis (48 cells)

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		0.3 ^a	0.3 ^a	1.2 ^b	1.8 ^b	2.0 ^b	3.6 ^b	5.3 ^b	6.6 ^b
1A	1.6	0.01	0.01	0.02	0.03	0.03	0.06	0.08	0.11
2A	5.3	0.02	0.02	0.06	0.10	0.11	0.19	0.28	0.35
1B	6.0	0.02	0.02	0.07	0.11	0.12	0.22	0.32	0.40
3A	7.5	0.02	0.02	0.09	0.14	0.15	0.27	0.40	0.50
3B	12.8	0.04	0.04	0.15	0.23	0.26	0.46	0.68	0.85
2B	21.3	0.06	0.06	0.26	0.38	0.43	0.77	1.13	1.41

C. monticola (48 cells)

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		10.5 ^a	10.7 ^a	14.8 ^b	18.7 ^b	20.4 ^b	32.6 ^b	44.1 ^b	66.9 ^b
1A	2.3	0.24	0.25	0.34	0.43	0.47	0.75	1.01	1.54
1B	6.0	0.63	0.64	0.89	1.12	1.22	1.96	2.65	4.01
3A	7.5	0.79	0.80	1.11	1.40	1.53	2.45	3.31	5.02
2A	8.6	0.90	0.92	1.27	1.61	1.75	2.80	3.79	5.75
3B	12.8	1.34	1.37	1.89	2.39	2.61	4.17	5.64	8.56
2B	34.4	3.61	3.68	5.09	6.43	7.02	11.21	15.17	23.01

Notes: Population Density estimates are in animals per square kilometer. ^aLine transect survey estimates. ^bNet hunt encounter estimates.

Meth refers to the three methods for calculating sustainable harvest rates described above, where A is the minimum value, and B the maximum value for each method.

SH is the predicted sustainable harvest rate as a percentage of the population.

The following tables present density estimates from Bayanga as well as elsewhere in Central Africa, and the corresponding sustainable harvest levels according to the rates described above.

A. africanus

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>					
		<u>2.7^b</u>	12.0 ^{c,d}	<u>17.6^b</u>	30.0 ^d	45.1 ^{e,f}	77.7 ^f
2A	9.9	0.27	1.19	1.74	2.97	4.46	7.69
1A	11.2	0.30	1.34	1.97	3.36	5.05	8.70
3A	15.0	0.41	1.80	2.64	4.50	6.77	11.66
1B	29.2	0.79	3.50	5.14	8.76	13.17	22.69
2B	39.5	1.07	4.74	6.95	11.85	17.81	30.69
3B	67.5	1.82	8.10	11.88	20.25	30.44	52.45

C. callipygus

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		0.6 ^c	<u>0.9^{a,b}</u>	1.1 ^a	3.2 ^g	<u>3.7^b</u>	6.7 ^c	10.7 ^f	15.0 ^h
1A	1.2	0.01	0.01	0.01	0.04	0.04	0.08	0.13	0.18
2A	5.5	0.03	0.05	0.06	0.18	0.20	0.37	0.59	0.83
1B	6.0	0.04	0.05	0.07	0.19	0.22	0.40	0.64	0.90
3A	7.5	0.05	0.07	0.08	0.24	0.28	0.50	0.80	1.13
3B	12.8	0.08	0.12	0.14	0.41	0.47	0.86	1.37	1.92
2B	21.8	0.13	0.20	0.24	0.70	0.81	1.46	2.33	3.27

C. dorsalis

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		<u>0.3^a</u>	1.3 ^b	1.5 ^g	2.5 ^c	6.3 ^h	<u>6.6^b</u>	6.8 ^c	7.1 ^f
1A	1.6	0.00	0.02	0.02	0.04	0.10	0.11	0.11	0.11
2A	5.3	0.02	0.07	0.08	0.13	0.33	0.35	0.36	0.38
1B	6.0	0.02	0.08	0.09	0.15	0.38	0.40	0.41	0.43
3A	7.5	0.02	0.10	0.11	0.19	0.47	0.49	0.51	0.53
3B	12.8	0.04	0.17	0.19	0.32	0.81	0.84	0.87	0.91
2B	21.3	0.06	0.28	0.32	0.53	1.34	1.41	1.45	1.51

C. monticola

<u>Meth</u>	<u>SH</u>	<u>Density estimates</u>							
		<u>10.5^a</u>	14.9 ^g	18.7 ^a	30.1 ^c	53.0 ^c	62.0 ^j	<u>66.9^b</u>	78.0 ^j
1A	2.3	0.24	0.34	0.43	0.69	1.22	1.43	1.54	1.79
1B	6.0	0.63	0.89	1.12	1.81	3.18	3.72	4.01	4.68
3A	7.5	0.79	1.12	1.40	2.26	3.97	4.65	5.02	5.85
2A	8.6	0.90	1.28	1.61	2.59	4.56	5.33	5.75	6.71
3B	12.8	1.34	1.91	2.39	3.85	6.78	7.94	8.56	9.98
2B	34.4	3.61	5.13	6.43	10.35	18.23	21.33	23.01	26.83

Notes: Underlined figures are estimated minimum and maximum densities in the Bayanga region according to transect surveys and Mossapoula day hunt encounters.

Meth refers to the three methods for calculating sustainable harvest rates described above, where A is the minimum value, and B the maximum value for each method.

SH is the predicted sustainable harvest rate as a percentage of the population.

Population densities are in individuals/km². Densities are determined from net hunt encounters near Mossapoula and around forest camps (Table 3.7), and are taken from the literature on sites in Gabon and Zaïre. For the duikers I have used density estimates only from other forest areas that include the same guild of duiker species--Gabon and Zaïre. For porcupines I have adapted Lahm's encounter rates according to the transect path width suggested by Payne; and I have adapted Emmons' home range data according to Feer and Dubost's assumptions of 7 individuals sharing one adult home range.

The resulting matrix is a set of permutations, given SH and D, for the number of individuals/km² that may be sustainably harvested.

Sources: For sustainable harvest rates (SH): 1) Cole, 1954; Robinson and Redford, 1991; 1994b; 2) Caughley, 1977; Caughley and Krebs, 1983; Feer, 1993; and 3) Bodmer et al., 1994.

For population densities (D): ^aNoss line transect surveys; ^bNoss net hunt encounters; ^cLahm, 1993; ^dPayne, 1992; ^eEmmons, 1983; ^fFeer, 1993; ^gHart, 1985; ^hFeer, 1989b; ^jDubost, 1980.

APPENDIX 4
WILDLIFE SPECIES BY CAPTURE METHOD
AND PROTECTION STATUS

<u>LATIN NAME</u>	<u>HAND</u>	<u>SPEAR</u>	<u>NET</u>	<u>SNARE</u>	<u>CROSSBOW</u>	<u>GUN</u>	<u>STATUS</u>
<u>MAMMALS</u>							
<i>Aonyx congia</i>		X		X		X	A
<i>Atherurus africanus</i>		X	X	X		X	C
<i>Atilax paludinosus</i>		X		X		X	B
<i>Bdeogale nigripes</i>		X	X	X		X	B
<i>Cephalophus callipygus</i>		X	X	X		X	B
<i>Cephalophus dorsalis</i>		X	X	X		X	B
<i>Cephalophus leucogaster</i>		X	X	X		X	B
<i>Cephalophus monticola</i>		X	X	X		X	B
<i>Cephalophus nigrifrons</i>		X	X	X		X	A
<i>Cephalophus sylvicultor</i>		X	X	X		X	B
<i>Cercocebus albigena</i>				X	X	X	C
<i>Cercocebus galeritus</i>			X	X	X	X	C
<i>Cercopithecus nictitans</i>				X	X	X	C
<i>Cercopithecus cephus</i>			X	X	X	X	C
<i>Cercopithecus neglectus</i>				X	X	X	C
<i>Cercopithecus pogonias</i>				X	X	X	C
<i>Colobus guereza</i>				X	X	X	A
<i>Cricetomys emini</i>		X		X		X	C
<i>Dendrohyrax arboreus</i>				X	X	X	C
<i>Felis aurata</i>				X	X	X	B
<i>Funisciurus pyrrhopus</i>				X			C
<i>Genetta servalina</i>				X		X	A
<i>Genetta tigrina</i>				X		X	C
<i>Genetta victoriae</i>				X		X	C
<i>Gorilla gorilla</i>		X		X		X	A
<i>Herpestes naso</i>		X	X	X		X	B
<i>Hippopotamus amphibius</i>						X	A
<i>Hyemoschus aquaticus</i>		X	X	X		X	A
<i>Hylochoerus meinertzhageni</i>		X		X		X	B
<i>Loxodonta africana</i>		X				X	A
<i>Lutra maculicollis</i>		X				X	A
<i>Manis gigantea</i>	X	X		X		X	A
<i>Manis tetradactyla</i>	X			X		X	C

<u>LATIN NAME</u>	<u>HAND</u>	<u>SPEAR</u>	<u>NET</u>	<u>SNARE</u>	<u>CROSSBOW</u>	<u>GUN</u>	<u>STATUS</u>
<u>MAMMALS (continued)</u>							
<i>Manis tricuspis</i>	X			X		X	C
<i>Mellivora capensis</i>		X	X	X		X	A
<i>Nandinia binotata</i>		X		X		X	C
<i>Neotragus batesi</i>		X	X	X		X	C
<i>Orycteropus afer</i>		X		X		X	A
<i>Pan troglodytes</i>		X		X		X	A
<i>Panthera pardus</i>				X		X	A
<i>Papio anubis</i>				X		X	C
<i>Perodicticus potto</i>	X			X		X	A
<i>Potamochoerus porcus</i>		X	X	X		X	B
<i>Procolobus badius</i>				X	X	X	A
<i>Protoxerus stangeri</i>				X			C
<i>Syncerus caffer</i>		X		X		X	B
<i>Thryonomys</i> sp.				X		X	C
<i>Tragelaphus euryceros</i>		X		X		X	B
<i>Tragelaphus spekei</i>		X		X		X	B
<i>Viverra civetta</i>		X		X		X	C
<u>REPTILES</u>							
<i>Bitis gabonica</i>	X	X		X			C
<i>Crocodylus cataphractus</i>	X	X		X		X	A
<i>Kinixys erosa</i>	X			X			C
<i>Osteolaemus tetraspis</i>	X	X		X		X	A
<i>Python sebae</i>	X	X		X			B
<i>Varanus niloticus</i>	X	X		X		X	A
<u>BIRDS</u>							
<i>Agelastes niger</i>			X	X		X	C
<i>Ceratogymna subcylindricus</i>					X	X	C
<i>Ceratogymna cylindricus</i>					X	X	C
<i>Ceratogymna atrata</i>					X	X	C
<i>Corythaeola cristata</i>							B
<i>Francolinus lathamii</i>			X	X			C

<u>LATIN NAME</u>	<u>HAND</u>	<u>SPEAR</u>	<u>NET</u>	<u>SNARE</u>	<u>CROSSBOW</u>	<u>GUN</u>	<u>STATUS</u>
<i>Francolinus squamatus</i>			X	X			C
<i>Guttera plumifera</i>			X	X		X	C
<i>Guttera pucherani</i>			X	X		X	C
<i>Lophaetus occipitalis</i>				X			C
<i>Stephanoaetus coronatus</i>				X			C

Source: République Centrafricaine, 1984.

Notes: The CAR wildlife code includes three levels of protection:

- List A = fully protected species, no hunting
- List B = partially protected species, may be hunted only with hunting license, head tax levied
- List C = unprotected species, may be hunted for food using traditional hunting methods

APPENDIX 5
OBSERVATION OF SNARE HUNTING

BAYANGA HUNTERS

<u>DATE</u>	<u>HUNTERS</u>	<u>SNARE NIGHTS</u>	<u>KGS</u>	<u>VALUE</u>
28 Sep 93	1	123	0.00	0
29 Sep 93	1	75	0.00	0
30 Sep 93	4	162	43.75	8,600
18-20 Oct 93	1	360	83.00	13,800
26 Jan-1 Feb 94	4	2,975	68.00	12,900
14-19 Feb 94	1	1,006	44.75	8,000
27 Feb-5 Mar 94	1	1,028	33.00	7,000
16-19 Mar 94	1	678	60.25	11,000
26-30 Apr 94	1	502	3.00	0
10-13 May 94	2	619	56.00	9,000
31 May-4 Jun 94	3	1,320	21.75	7,500
15-19 Jun 94	2	1,036	47.85	13,000
25 Jun-2 Jul 94	1	1,919	56.00	16,400
8-13 Aug 94	1	777	7.00	2,500
3-8 Oct 94	2	1,079	101.45	23,800
8-12 Nov 94	2	1,050	17.75	3,750
2-4 Dec 94	5	2,111	142.50	25,250
7-10 Dec 94	2	1,836	23.25	3,650
TOTAL	17	18,656	819.80	167,350

MOSSAPOULA HUNTERS

13 Dec 93	1	48	0.00	0
9-14 Jan 94	1	86	13.50	1,200
23 Feb 94	1	80	0.00	0
TOTAL	3	214	13.50	1,200

APPENDIX 6 BAYANGA SNARE AND GUN HUNTING OFFTAKES

Hunting offtakes by species from snare hunting are calculated according to data from observed captures, and from surveys of bushmeat markets in Bayanga as well as exports on public buses.

Observed Captures: Data Set 1

Observed captures are from 17,803 snare nights, excluding fence snares. Total captures are from an estimated 1,533,000 total annual snare nights for Bayanga hunters based on the following conservative assumptions: 60 hunters, and 70 snares per hunter.

<u>Species</u>	<u>Observed Captures</u>	<u>Total Captures</u>	<u>Percent of red</u>
Red duikers	45	3,874.9	
<i>C. callipygus</i>	36	3,099.9	80.0
<i>C. dorsalis</i>	7	602.8	15.5
<i>C. leucogaster</i>	1	86.1	2.2
<i>C. nigrifrons</i>	1	86.1	2.2
<i>C. monticola</i>	38	3,272.1	
<i>A. africanus</i>	11	947.2	
Monkeys	2	172.2	
<i>P. porcus</i>	2	172.2	
Other	11	947.2	
Total	109	9,385.8	

The red duiker category includes four medium-sized duikers: *C. callipygus*, *C. dorsalis*, *C. leucogaster* and *C. nigrifrons*. However, *C. callipygus* represents 80 percent of captures, *C. dorsalis* 15.5 percent, and the other two species only 2.2 percent each. Red duikers are 54.2 percent of all duiker captures, with blue duikers making up the remaining 45.8 percent. The "other" category includes four tortoises that were collected by snare hunters, but that were not captured in snares.

Neighborhood Surveys: Data Set 2

Ndombe Blaise conducted a neighborhood survey of bushmeat for sale from May to December 1994: for a total of

192 observation days he recorded the quantity of meat available in pieces or in whole animals, and whether the animals were killed with snares or guns. He did not distinguish any of the red duikers, and figures by species were calculated according to the proportions in the capture data above. Quantities in pieces were converted to numbers of whole animals according to established market practices: *C. monticola* and monkeys sold in halves, red duikers sold in quarters. *C. sylvicultor*, *P. porcus* and *T. spekei* are conservatively assumed to produce six pieces of meat, while *T. euryceros* accounts for at least ten.

However, the data on wastage among observed captures suggests that 27 percent of animals captured in snares are lost to scavengers or decomposition. Therefore the number of animals reaching the market represents only 73 percent of the number killed. Presumably there is no wastage by gun hunting, although some animals may escape with fatal injuries.

Species	<u>SNARES</u>		<u>GUNS</u>		<u>TOTAL</u>	<u>Percent</u> <u>Guns</u>
	<u>N</u>	<u>Annual</u> <u>Total</u>	<u>N</u>	<u>Annual</u> <u>Total</u>		
Red duikers	264.5	674.0	209.8	398.8	1,072.9	37.2
<i>C. callipygus</i>	211.6	539.2	167.8	319.1	858.3	
<i>C. dorsalis</i>	41.1	104.8	32.6	62.0	166.9	
<i>C. leucogaster</i>	5.9	15.0	4.7	8.9	23.8	
<i>C. nigrifrons</i>	5.9	15.0	4.7	8.9	23.8	
<i>C. monticola</i>	221.0	563.2	168.0	319.4	882.6	36.2
Monkeys	84.5	215.3	209.8	398.8	465.3	53.7
<i>P. porcus</i>	15.2	38.7	10.7	20.3	59.1	34.4
Other	18.0	45.8	29.0	55.1	100.9	54.6
Total	603.2	1,537.1	549.0	1,043.7	2,580.8	

Market and Export Surveys: Data Set 3

The project personnel Godia Guembi Jules and Maka Sylvestre conducted a survey over 212 observation days, from May to November 1994, to record exports of bushmeat from Bayanga on public buses, as well as quantities of meat for sale in local informal markets. Meat exports were recorded only as quantities of pieces of meat. These figures were disaggregated in several iterations: first, according to the relative proportions of snare and gun hunting in producing bushmeat suggested by the neighborhood survey; second, according to the relative proportion of duikers, monkeys, and bush pigs in the bushmeat supply in the market survey data; third, according to the proportions of red and

blue duikers in the supply of duiker meat in the neighborhood survey data; and fourth, according to the relative proportions of the four red duiker species in observed captures. The bushmeat market data for the most part distinguished monkeys, bush pigs, and duikers; thus providing information on the relative importance of these three categories of meat. The data on duikers were disaggregated as described above. Again, the figures for snare captures reaching markets are assumed to represent only 73 percent of total animals killed by this method.

<u>Species</u>	<u>Markets</u>	<u>Exports</u>	<u>Annual Guns</u>	<u>Annual Snare</u>	<u>TOTAL</u>
Red duikers	1,011.1	947.2	1,253.3	2,839.3	4,092.6
<i>C. callipygus</i>	808.8	757.7	1,002.7	2,271.4	3,274.1
<i>C. dorsalis</i>	157.3	147.3	195.0	441.7	636.6
<i>C. leucogaster</i>	22.5	21.0	27.9	63.1	90.9
<i>C. nigrifrons</i>	22.5	21.0	27.9	63.1	90.9
<i>C. monticola</i>	831.7	779.1	1,003.6	2,372.3	3,376.0
Monkeys	405.1	322.4	673.0	777.1	1,450.1
<i>P. porcus</i>	93.6	74.2	99.5	253.9	353.4
Other	61.7	57.8	101.5	139.5	241.0
Total	2,403.2	2,180.7	3,131.0	6,382.2	9,513.2

Combined Total Offtakes

Only the first data set provides information on *A. africanus* captures. These small animals are usually eaten by the hunters rather than sold. The second data set, based on only one neighborhood of Bayanga, underestimates total offtakes for all species. The third data set did not survey all Bayanga markets either, therefore actual offtakes should exceed the surveyed offtakes. As expected, estimated annual market/export survey offtakes for duikers are only 73 percent of estimated offtakes from observed captures. However, the highest figures for monkeys and bush pig are from the third data set. Total annual offtake can then be calculated using the porcupine and duiker figures from data set 1, and adjusting the monkey, bush pig, and "other" figures from data set 3, assuming that the latter represent only 73 percent of actual offtake.

<u>Species</u>	<u>Snares</u>	<u>Guns</u>	<u>Total</u>
Red duikers	3,875	1,711	5,585
<i>C. callipygus</i>	3,100	1,368	4,468
<i>C. dorsalis</i>	603	266	869
<i>C. leucogaster</i>	86	38	124
<i>C. nigrifrons</i>	86	38	124
<i>C. monticola</i>	3,272	1,384	4,656
Monkeys	1,060	922	1,982
<i>A. africanus</i>	947	--	947
<i>P. porcus</i>	346	136	483
Other	1,051	139	1,190
Total	10,552	4,292	14,844

APPENDIX 7
OBSERVATION OF COMMUNAL NET HUNTING

Preliminary

1993 September 20-24
 October 11-15

Principal

1993 December 6-10
 December 13-17
1994 January 3-7
 January 17-21
 February 7-11
 February 21-25
 March 7-11
 March 21-25
 April 18-22
 May 2-6
 May 16-20
 June 6-10
 June 20-24
 July 4-8
 August 1-5
 August 29-September 2
 October 10-14
 November 21-25

Forest Camps

1993 October 6-8
1994 August 21-27
 September 5-10

APPENDIX 8
FOODS COMMONLY GATHERED BY NET HUNTERS

Important foods other than meat collected by net hunters include 7 types of nuts, 24 types of mushrooms, 8 types of caterpillars, and 10 types of honey.

NUTS

<u>BaAka name</u>	<u>Scientific name</u>
Bokana	<i>Panda oleosa</i>
Bokoko	<i>Klainedoxa gabonensis</i>
Bosombo	<i>Irvingia grandifolia</i>
Ekobo	<i>Ricinodendron heudelotii</i>
Mokombebe	<i>Irvingia robur</i>
Mujali	<i>Antrocaryon micraster</i>
Payo	<i>Irvingia excelsa</i>

Note: All botanical identifications by David Harris.

MUSHROOMS

<u>BaAka name</u>	<u>Gbaya name</u>	<u>Season</u>	<u>Description</u>
Bala		Jun	Light brown, darker center, 5 cm stem, 3 cm top
Banyavya	Napeya	Mar/Oct	Yellow, 5 cm top, 5 cm stem, <i>G. dewevrei</i> monodominant forest
Basumbu		May	Peach, 2 cm stem, 8 cm across, "chimpanzee ears"
Bitoto		Oct	White, short stem
Bokata	Nzekebe	Jan/Oct/Apr	Shelf, white
Elokoabakema			
Ewayi			
Guruyabemba	Bebemu	Feb	Dark Yellow, stem, black on top
Kpoda	Kpangundang		Dark, shelf
Maita		May	Yellow, 8 cm top, 8 cm stem
Makodu	Indele	March	Shelf, rubbery, dark brown

MUSHROOMS (continued)

<u>BaAka name</u>	<u>Gbaya name</u>	<u>Season</u>	<u>Description</u>
Mandongo	Puru		Tiny dark, stem
Mbongo	Bolda	Mar/Apr	White, 8 cm stem, 5 cm top
Mbudi	Gbaze		Black, large, thick short stem
Mombindombindo			
Muséle	Gbadole	Mar/Oct	White, 30 cm across, long stem
Mwoluwolu			
Njinga	Njinjinjila	Mar/May	Red-brown top, white underside, 10-15 cm top, 10 cm stem
Njobolobo		Mar/Aug	Grey, 6-8 cm top, 6 cm stem
Sekeseke		Apr	Black thin stem 10 cm, white/purple 5 cm top, umbrella shape
Sembasemba	Buanjeme	Mar	White, <1 cm top
Senjusenju			Black, stem
Tokomba	Gogor	Sep/Oct	Pink/grey, 2-3 cm cup top
	Sakosa		Grey, long stem

Note: Mushrooms probably belong to the following genera: *Auricularia*, *Collybia*, *Cookeina*, *Coprinus*, *Favolus*, *Heliomyces*, *Langermannia*, *Lentinus*, *Lepiota*, *Marasmius*, *Pluteus*, *Termitomyces* and others (Bahuchet, 1985b; Berry et al., 1986).

CATERPILLARS

<u>BaAka name</u>	<u>Scientific name</u>	<u>Food tree</u>
Bosó		<i>Nauclea</i> spp.
Boyó	<i>Imbrasia oyemensis</i>	<i>Entandrophragma cylindricum</i>
Bokanga		<i>Entandrophragma candollei</i>
Eloko		<i>Entandrophragma angolense</i>
		<i>Nauclea</i> spp.
Membambanga	<i>Imbrasia truncata</i>	<i>Lophira alata</i>
Mopeipei		<i>Lophira alata</i>
Ndosi	<i>Anaphe venata</i>	<i>Polyathia sauveolens</i>
	<i>Anaphe infracta</i>	<i>Triplochiton scleroxylon</i>

Note: Scientific names are from Bahuchet (1985b) and Berry et al. (1986). In addition, they list the following edible caterpillars for CAR forests: *Anaphe* sp., *Bunaea alcinoë*, *Cirina forda*, *Imbrasia epimethea*, *I. obscura*, *Lobobunea* sp., and *Pseudantherea discrepans*.

HONEY BEES

<u>BaAka name</u>	<u>Scientific name</u>	<u>Description</u>
Béni		Stingless
Boi	<i>Apis mellifica</i> ?	Hive in hollow trees
Dungi		Fierce sting, hive in ground
Fende	<i>Meliplebeia beccarii</i>	Stingless
Kuma	<i>Meliponula bocandei</i>	Stingless
Mamboya		Stingless
Mangé		Stingless
Mokó		Stingless
Ndigba	<i>Trigona</i> sp.	Stingless
Obá	<i>Apotrigona nebulata</i>	Stingless
Sakó	<i>Axestotrigona erythra</i>	Stingless, hive in hollow trees

Note: Scientific names are from Bahuchet (1985b) and Ichikawa (1981), who also list the following species for CAR and Zaïre respectively: *Apotrigona* spp., *Axestotrigona simpsoni*, *Axestotrigona tescorum*, *Dactylurina staudingeri*, *Hypotrigona braunsi*, *Hypotrigona gribodoi*, and *Pleiella lendiana*.

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BIOGRAPHICAL SKETCH

Born in 1964 in Wisconsin, Andrew J. Noss grew up in Cameroon and attended Hillcrest High School in Jos, Nigeria. After graduation from Carleton College (Northfield, Minnesota) with a B.A. in international relations 1986, he spent a Watson Fellowship year studying economic development programs in Africa. In 1989 he received an M.A. in international economics and social change and development from the Johns Hopkins University School of Advanced International Studies in Washington, D.C. He worked in the World Bank's Population and Human Resources Department before pursuing a Ph.D. in geography and African studies at the University of Florida, where he enrolled in 1991.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Edward J. Malecki, Chair
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



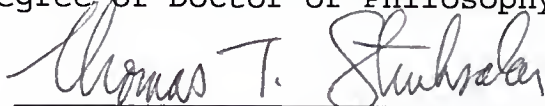
Abraham C. Goldman, Cochair
Assistant Professor of
Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Nigel J.H. Smith
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Thomas T. Struhsaker
Professor of Forest Resources and
Conservation

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Richard E. Bodmer
Assistant Professor of Wildlife
Ecology and Conservation/Latin
American Studies

This dissertation was submitted to the Graduate Faculty of the Department of Geography in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December 1995

Dean, Graduate School

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